APPENDIX C

VALVE PRODUCT INFORMATION

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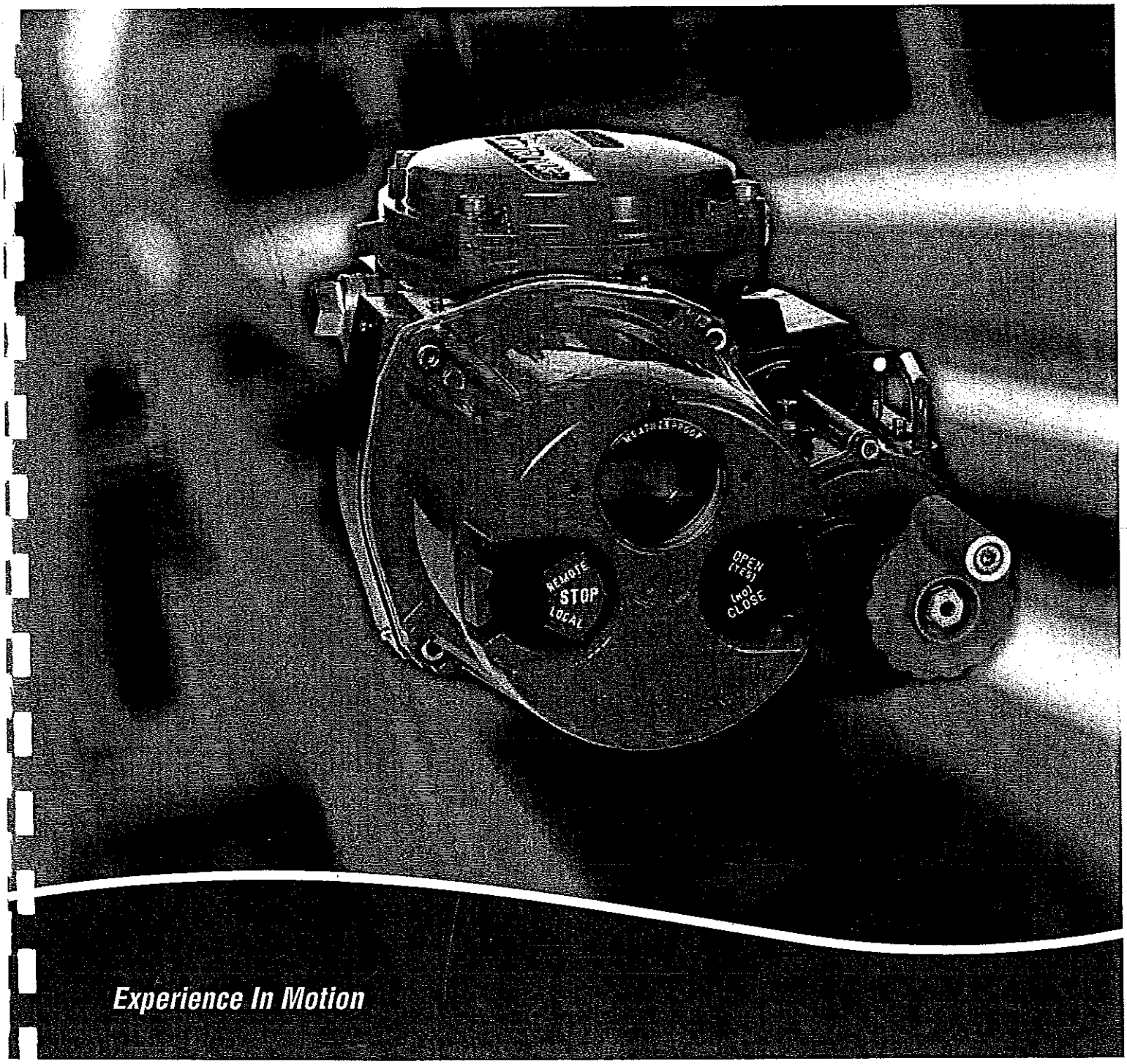
Limitorque QX

The Next Generation in Smart Quarter-turn Actuation



Experience In Motion

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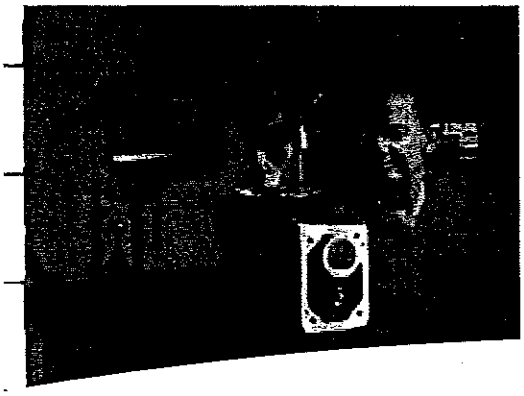
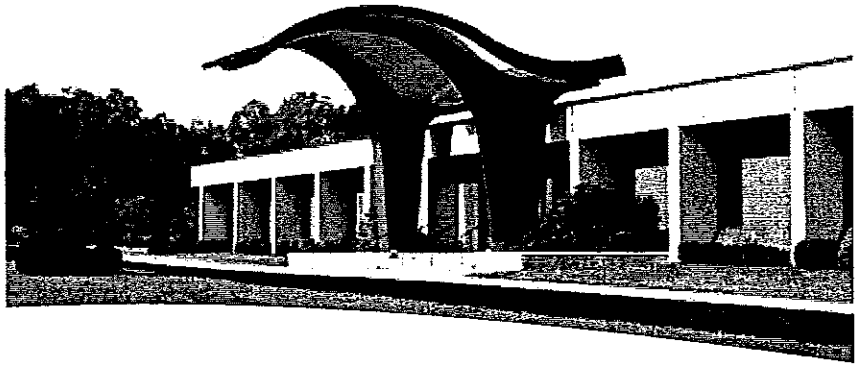




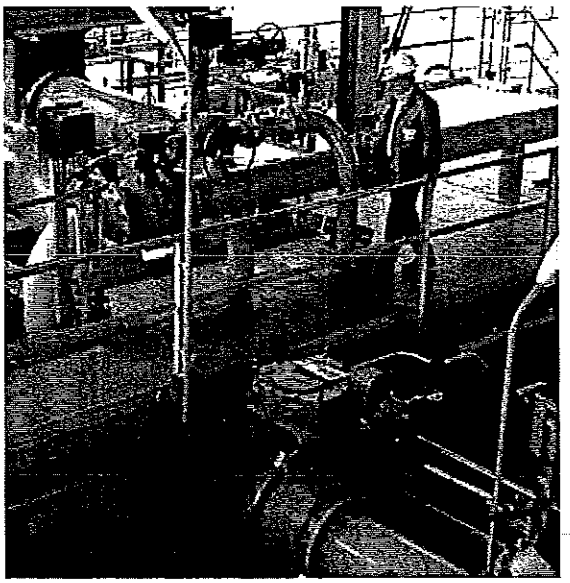
Flowserve Limitorque Actuation Systems

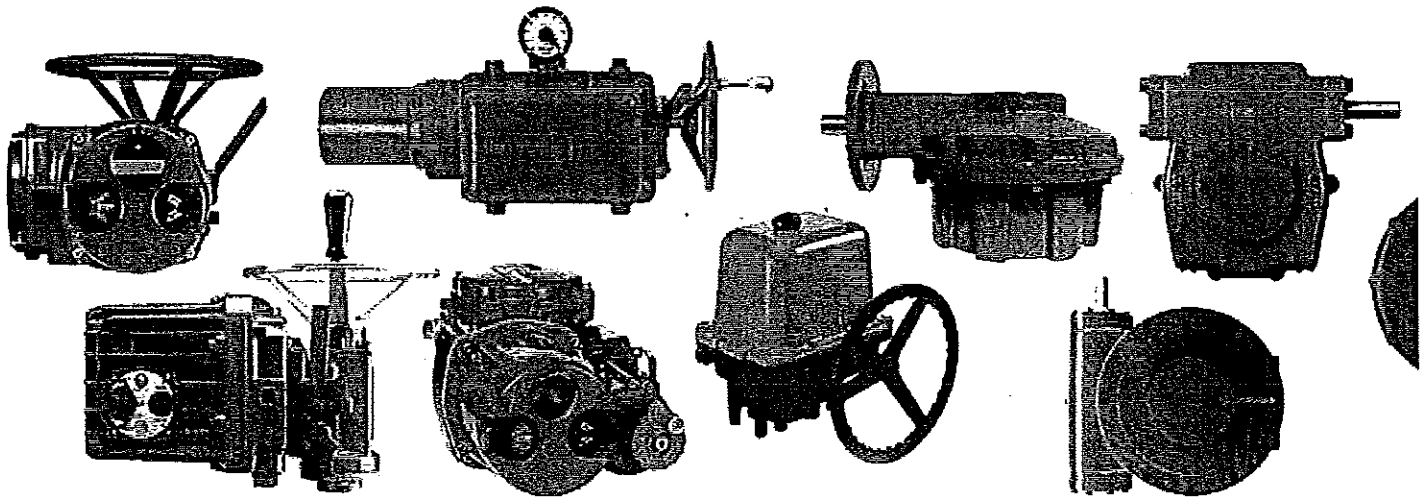
Limitorque is an operating unit of Flowserve, a $4 billion-plus/year company strongly focused on automation and support of the valve industry. Flowserve is the world's premier provider of flow management services.

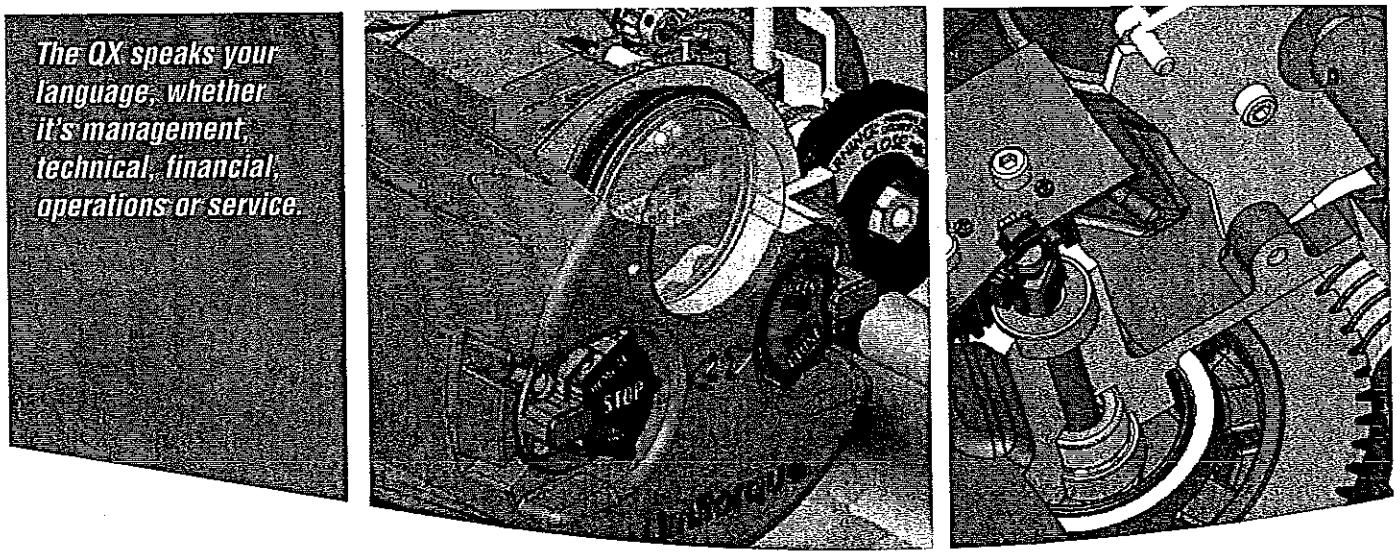
Limitorque has evolved over 80 years since its strategic introduction of a "torque-limiting" design that changed an industry. Flowserve Limitorque offers solutions and automation choices for customers that provide:

- Cost savings from field devices such as electric valve actuators
- Greater operating efficiencies from control-room performance sequencing, interlocking and continuous process optimization
- Competitive advantages derived from increased management visibility of databases and networks

Limitorque is one of the primary reasons Flowserve is "Experience In Motion."





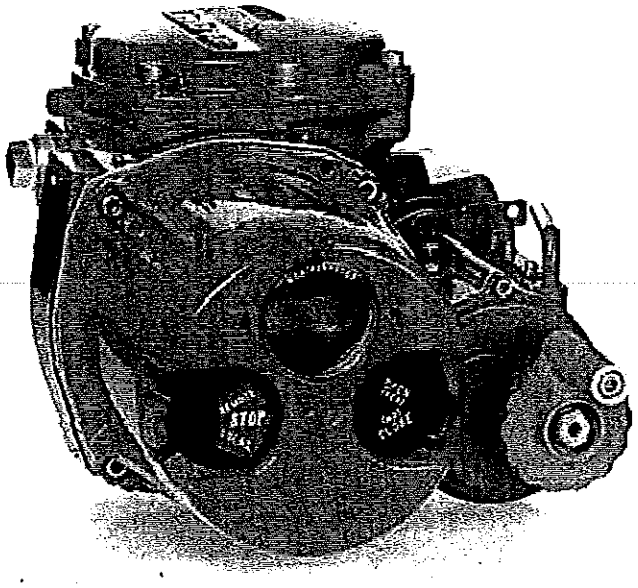


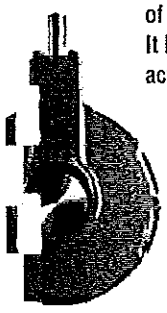
Limitorque QX Smart Valve Actuator

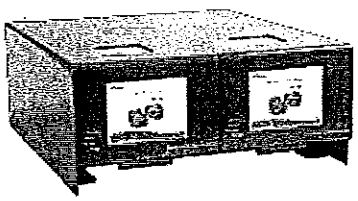
The full measure of safety and reliability in the next-generation smart quarter-turn actuator.

The Flowserve Limitorque QX quarter-turn smart electronic valve actuator continues the legacy of the industry's state-of-the-art, non-intrusive, multi-turn MX actuator by including a patent-pending absolute encoder for tracking position without the use of troublesome batteries. The QX design provides enhanced safety and reduced downtime through improved diagnostics, built-in self-test (BIST) features and LimiGard™ fault protection.

The QX design builds on more than 10 years of experience with proven Limitorque MX technology—the first-generation double-sealed electronic valve actuator from Flowserve designed to provide control, ease of use and accuracy. The QX includes all the user-preferred features of the MX in a quarter-turn smart actuator package. It is the only non-intrusive, double-sealed quarter-turn actuator to display the Limitorque brand.







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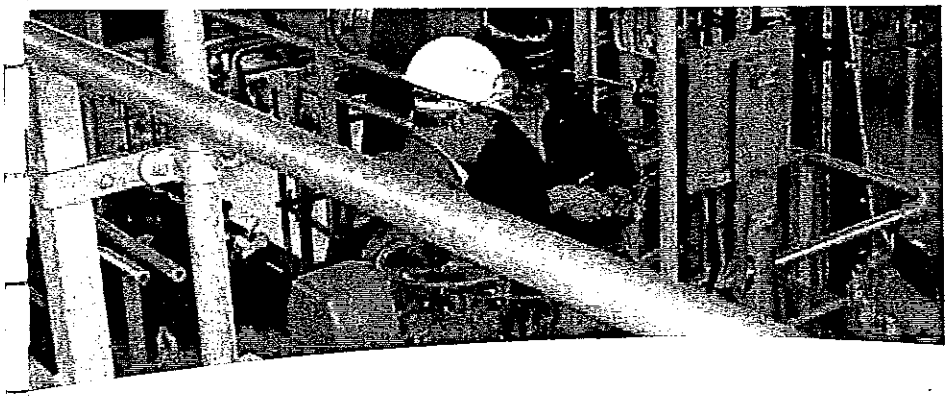
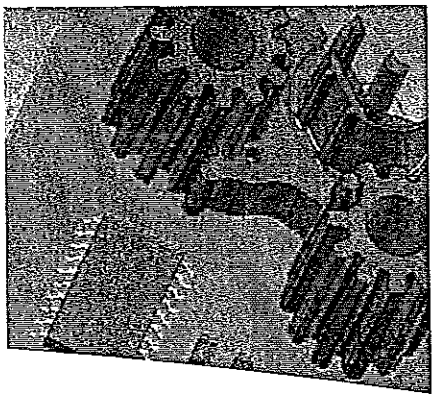




QX: The Next Generation in Smart Quarter-turn Actuation

Speed, Precision and Simplicity

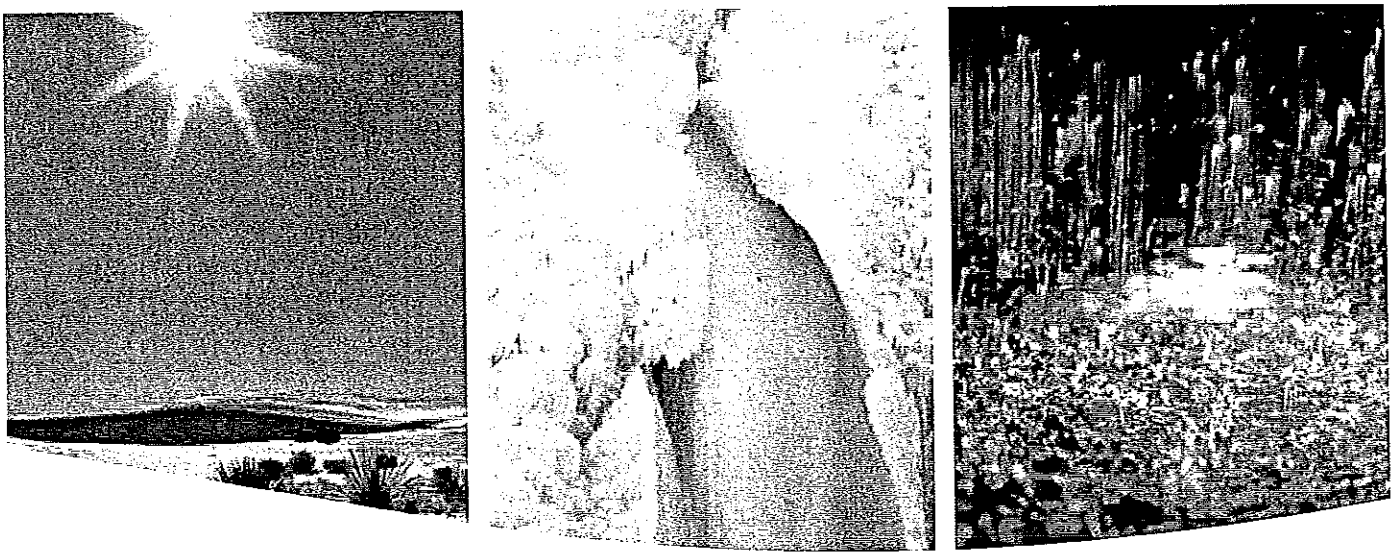
The QX control panel features an improved 32-character LCD screen that provides actuator status and diagnostics in an easy-to-use, easy-to-read, graphical format. The industry's first non-intrusive, quarter-turn multilingual actuator is configurable in English, Spanish, German, French, Italian, Portuguese, Mandarin, Russian, Bahasa Indonesia and Katakana as standard configuration languages. In addition, the LCD can be rotated 180° for better field visibility.

User friendliness, precision, simplicity, and intuitive setup are characteristics expected of a smart actuator. Users and valve OEMs demand quick setup and easy-to-understand dialogue in preferred languages. The ability to either upload new software or download diagnostics is also critical to improving a plant's efficiency. The QX provides customers with the essential tools for rapid installation and root-cause diagnostics.

Precision is expected in a smart actuator. The MX was the first such device developed with a patented absolute encoder that doesn't require troublesome and unpredictable battery backup. Flowserve Limitorque's innovative absolute encoder technology, developed for the MX, is used in the QX. The QX encoder employs system-on-chip technology using a contactless magnet that excites Hall-effect devices to provide redundant, 12-bit resolution over 360 degrees. This redundancy, part of the BIST (built-in self-test) feature, means the device can continue to function reliably until a number of faults have been accumulated.

When a device is designed for BIST, its methodology is such that much of the test functionality is embedded in the device itself. BIST design enables a critical component's ability to communicate its actual state to a CPU for comparison to the expected state. Any deviation from expected values will be reported to the user, with correlation to the failed component or subsystem.

Simplicity is expected in a smart actuator. In fact, one of the reasons for using an electronic actuator is the simplicity of setup, installation on a valve and acquiring diagnostic information. The QX is the simplest and easiest to use electronic quarter-turn actuator.



Long Life and Protection

Long life is expected in a smart actuator. There are more than 1,000,000 Limitorque actuators installed around the globe, in every conceivable environment. Many have been functioning for over 50 years. This legendary Limitorque longevity has been carried over into the QX family of smart actuators. The QX has been developed with the ruggedness and dependability users have come to expect from Limitorque actuators for better than 80 years.

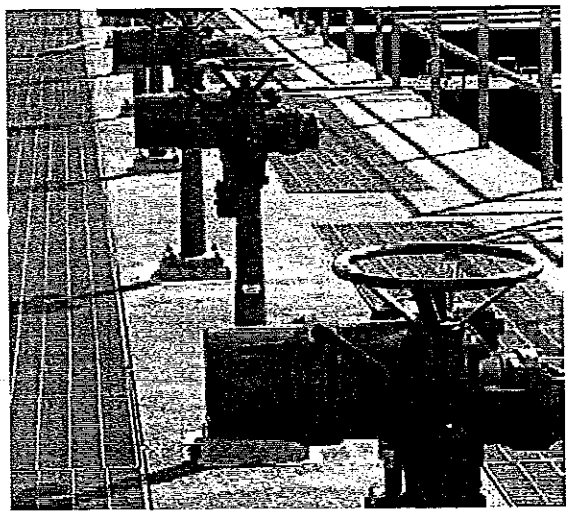
In order to last a long time in severe environments, smart actuators must have unparalleled protection. The QX's IP68 enclosure rating is 20M for 168 hours, regardless of whether the unit is weatherproof or explosion-proof. This is an industry-leading feature. Add other certifications to the list – NEMA 4, 4X, 6 – and the QX is unsurpassed in unit protection.

The QX is double-sealed, which isolates the terminal compartment from the controls environment. Any leakage into the terminal compartment is contained in the compartment.

The QX is powder coated using a polyester resin in Dupont Blue Streak color, not only for aesthetics, but also for protection in severe corrosive environments. The use of powder coating ensures that each QX can withstand saliferous conditions without degradation.

Quality and Certifications

Flowserve Limitorque is a global leader in quality manufacturing. All Limitorque plants are certified to ISO 9001 standards, the recognized benchmark for quality all over the world. The same unexcelled use of certified



materials is found in the QX as in Limitorque's naval and nuclear-qualified electric actuators. The MX has used synthetic gear oils especially optimized for use with worm-gear sets since the first unit was shipped in 1997, and the QX is no exception. All lubrication used in the QX is synthetic, capable of temperature extremes from -60°C to +70°C. The MX was the first non-intrusive actuator to use rolled worms and electronic controls designed and produced using surface-mount technology: the QX uses components manufactured with the same advanced technology. A true globally certified device, the QX meets all pertinent European directives including ATEX, EMC, Machinery and Noise, and displays the CE mark associated with such compliance.

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Anatomy of QX Quarter-turn Actuators

Limitorque QX actuators respond to customer needs with advanced features designed for ease of commissioning and use, as well as time- and money-saving operational benefits. What sets the QX apart is the combination of control and reliability enabled by advanced Limitorque technology, plus superior ergonomics and human interfaces for speed, comfort, and ease of use.

Brushless DC Motor
Advanced brushless DC motors eliminate sparks, reduce mechanical and electrical noise, and dissipate heat better than brushed motors. Unique to the industry, brushless motors last longer than conventional motors and allow for more accurate positioning while permitting a global range of voltages (single-phase and three-phase AC and DC) to be used without modification.

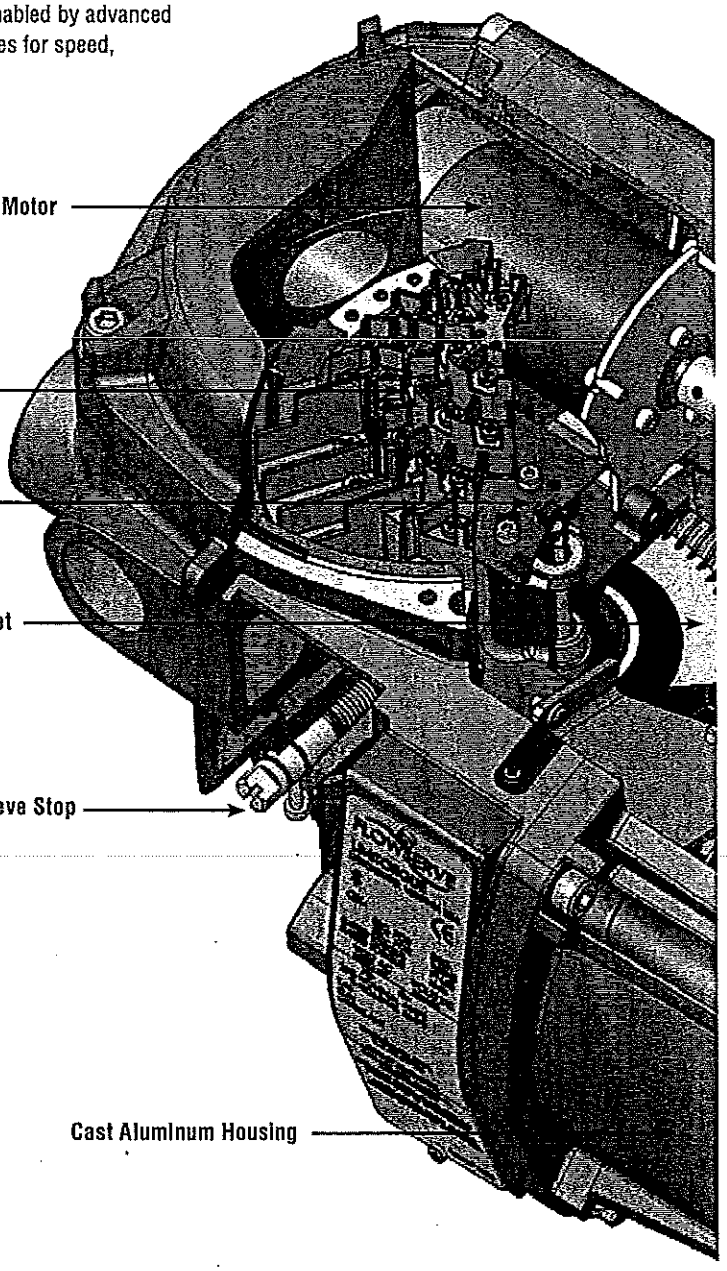
Terminal Chamber
Double-sealed design provides a termination chamber that is separate and sealed from the control chamber. Control components are never exposed to the elements during site wiring or because of a faulty cable connection.

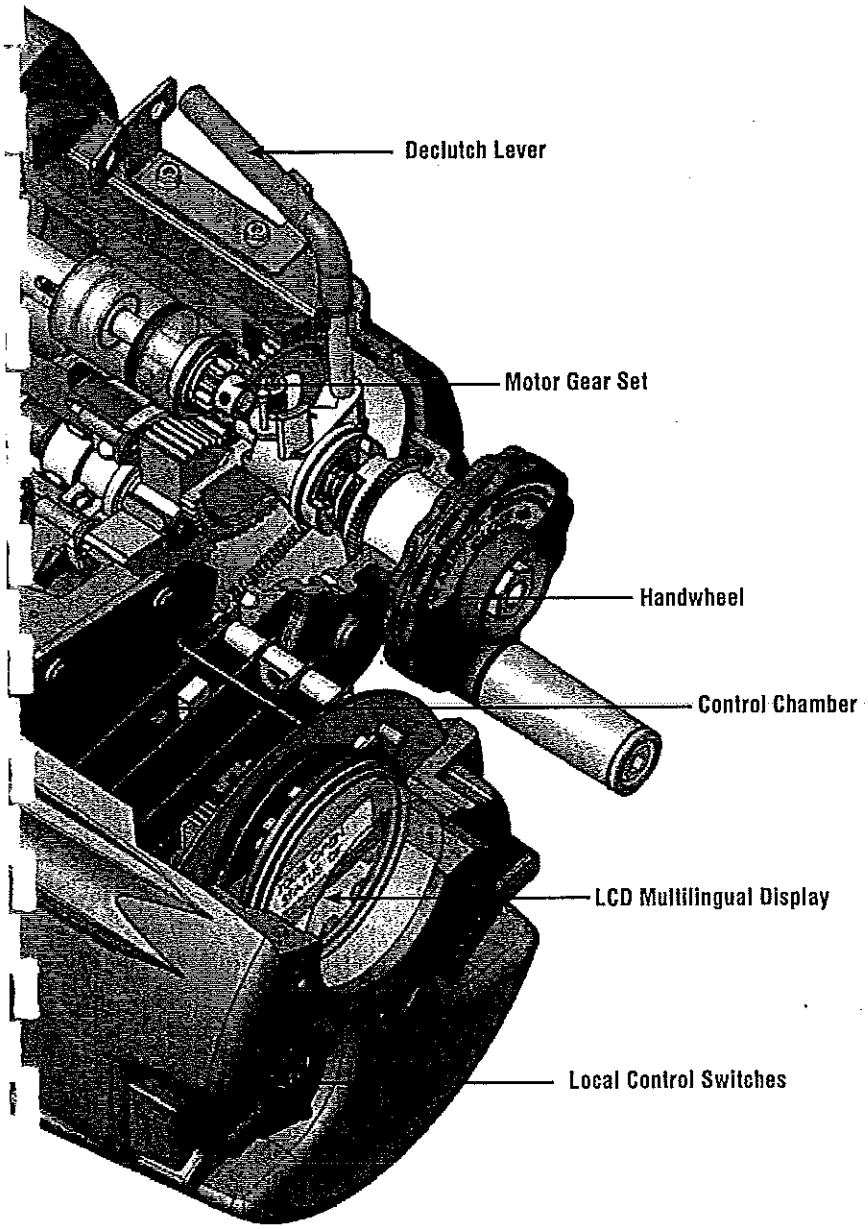
Absolute Encoder
The QX encoder employs system-on-chip technology using a non-contacting magnet to excite Hall effect devices, providing redundant, 12-bit resolution over 360°. This redundancy, part of the BIST feature, means the device can continue to function reliably until a number of faults have been accumulated.

Worm Gear Set and Motor Gear Attachment
Both the motor gear reducers and worm gear sets are designed with Limitorque performance and longevity in mind. Rolled/ ground gears are bearing supported and immersed in an extended life synthetic gear oil specifically designed to improve efficiency and minimize wear.

Drive Sleeve Stop
Drive sleeve stops are supplied for 90° selections and removed for multi-turn applications, up to 20 turns maximum.

Cast Aluminum Housing
The QX housing material is cast 356-T6 grade aluminum. This alloy was selected due to its superior suitability for corrosion resistance in harsh and eroding environments.





Declutch Lever
Declutch lever enables the QX actuator to be placed in manual, handwheel-drive operation. Lever automatically disengages when motor is energized and can be padlocked in the motor position.

Torque Sensing
The QX continues the Flowserve Limitorque commitment to fully electronic smart actuators with advanced torque sensing. This method of torque control uses motor amperage to sense the valve load and has been verified in temperature extremes from -30°C to +70°C.

Handwheel
QX handwheels are manufactured from an engineered resin and are designed to meet most minimum rim pull requirements. Locating the handwheel adjacent to the LCD and controls facilitates local configuration and operation.

Control Chamber
Utilizing the same electronics package as the state-of-the-art MX, the QX has an additional feature - a solid state motor controller. This design permits almost all customer supplied voltages, single or three phase AC or DC, to be connected without modification to the voltage supply.

LCD Multilingual Display
The control panel display delivers instant, up-to-the-minute actuator status and valve position in 10 languages. It also provides simple calibration and diagnostic information, including motor, identification, and hardware data, as well as torque profile and log reports.

Local Control Switches
Local control switches make setup and calibration easy, using "yes" or "no" responses to straightforward questions, plus they provide the ability to open, stop and close the actuator and to select remote or local preferences. These switches are magnetically coupled, solid-state Hall effect devices, which eliminate troublesome and fragile reed switches.

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Control and Diagnostics

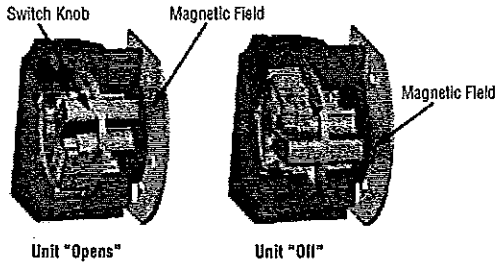
Control is expected in a smart actuator. The QX simplifies valve automation in three critical methods of control:

- Calibration/setup
- Normal operation
- Diagnostics and troubleshooting

The MX was the first non-intrusive actuator to equip users with LCD dialogue screens in the language of their choice. The QX has the same language options as the MX and uses a graphical dot matrix display that improves the visibility of the display. The use of this type of LCD permits the support of any language. In fact, in addition to English, Spanish, German, French, Italian and Portuguese, the QX also includes four character-based languages – Mandarin, Russian, Bahasa Indonesia and Katakana – with a capacity for even more.

Simple "Yes" and "No" responses to dialogue questions confirm the setup of the QX via solid-state Hall effect devices in both knobs. No special tools or remote devices are required. And the QX is "fit for service", offering the widest range of configuration menus of any non-intrusive smart actuator.

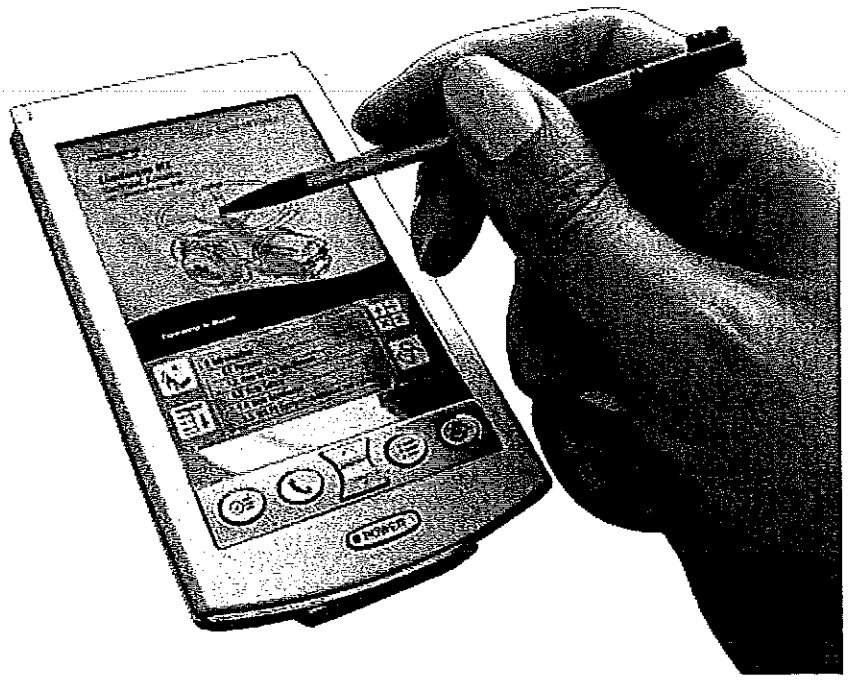
Diagnostics should be easy to read and decipher. The QX diagnostic enhancements now offer a BIST (built-in self-test). The BIST feature is also designed into a state-of-the-art controls platform that verifies and validates the integrity of its components. The result is a design that aids the user in meeting the SIL (Safety Integrity Level) requirements of IEC 61508. Placing a smart device into any plant system enhances the ability of a given safety system to achieve its preferred SIL rating. Any device that incorporates fully developed BIST features provides assurance to the user that the device has been designed with plant-wide safety and integrity of operation in mind.

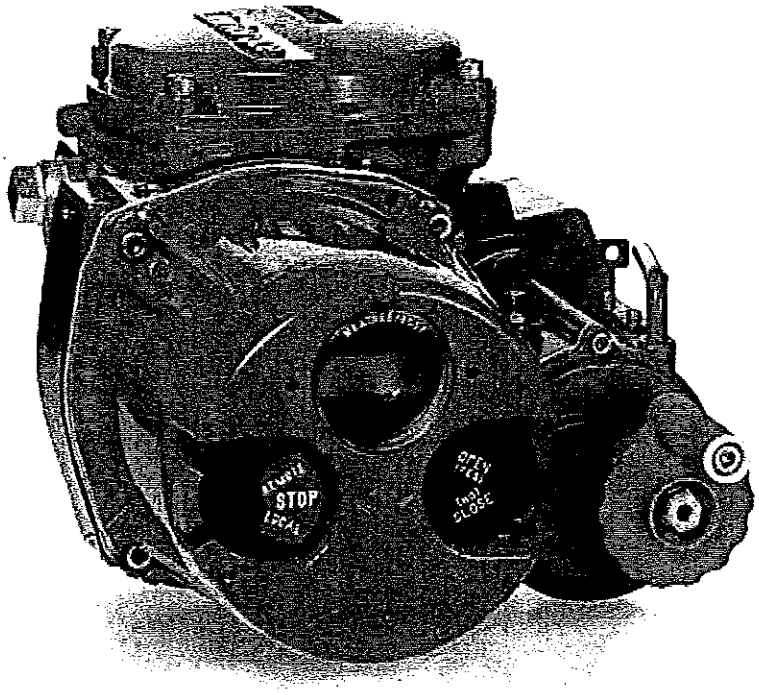


NOTE: Illustration for information only.

Hall effect devices interlocked to prevent operation

The "View Diagnostics" menu selections now include more definitive routines that can isolate troubleshooting to "root cause" error codes. These root-cause codes can be used in conjunction with BIST. A well-designed BIST-based system can do more than just report failures in the electronic subsystems: it can also determine failures or

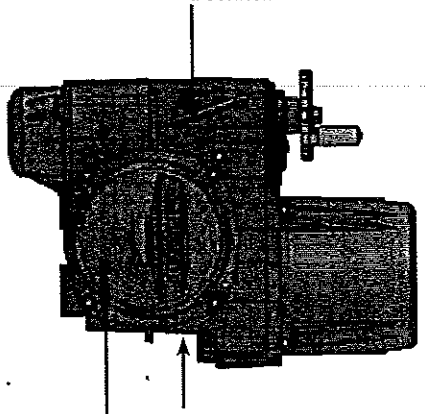




predict future failures in its associated mechanical system. To further enhance QX diagnostics, a new component has been added to the patented Limigard feature – Frequency Domain Analysis.

The Frequency Domain Analysis (FDA) methodology for QX is based upon capturing torque, position or speed values at regular time intervals while the actuator is motoring, and then calculating the resulting data set with a Fast Fourier Transform (FFT). This converts the actuator's torque, position or speed signature from the time to the frequency domain. The resulting information is very useful at pinpointing any components in the mechanical drive train that have failed or are about to fail. Only the QX or MX has the FDA feature in its View Diagnostics menus.

The QX also offers Bluetooth technology as an option, up to 10 meters. When used with the Flowserve Limitorque graphical software interface, Dashboard™, diagnostic information can be transferred easily to a PDA with Windows Mobile 5 or greater, laptop computer or smart cell phone. In addition, off-line configuration changes can be uploaded and actuator configurations transferred from one device to any number of subsequent actuators.



Three conduit openings are standard with the option of a fourth.

Terminal Compartment *with O-ring seals that permit a double-sealed compartment, isolating the electronic controls from the environment.*

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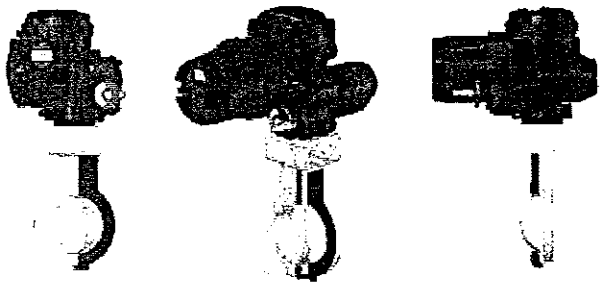
Nothing Exceeds Limitorque QX Actuators for Ease and Compatibility with Quarter-turn Valves of All Types



Valves

Limitorque QX actuators have been designed to accommodate today's wide variety of valve designs and configurations and meet international standards for valve and actuator interfaces, including ISO 5210 and MSS SP-102.

Direct mounting: The QX can be directly coupled with all quarter-turn valves for position seated or torque-only applications.

Couplings

Standard B4/B4E Base

The standard QX actuator base includes a mounting base for torque-only or position-seated valves. It also includes a steel torque nut, which may be machined to fit a valve or, if necessary, gearbox. A B4E torque nut can be provided and may be installed to allow for extended stem acceptance.

Available QX Flanges

		QX-1	QX-2	QX-3	QX-4	QX-5
Flange 1	ISO 5210	F05/F07	F07	F10	F12	F12
	MSS SP-102	FA05/07	FA07	FA10	FA12	FA12
Flange 2	ISO 5210	F10	F10	F12 F14	F12 F14	F14
	MSS SP-102	FA10 (STD)	FA10 (STD)	FA12 FA14	FA12 FA14	FA14

Integrity and Predictable Performance

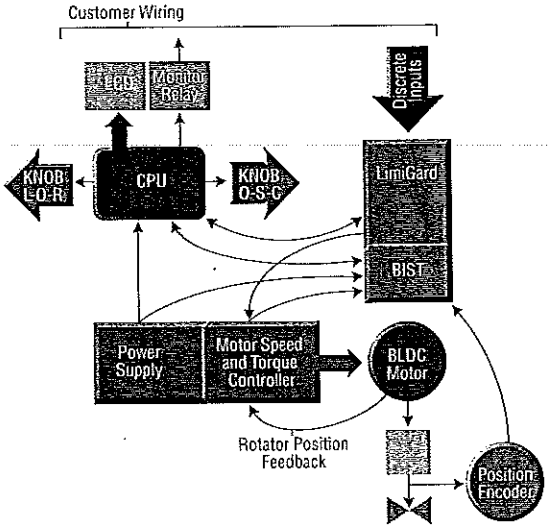
Smart actuators should have enabling technologies that ensure integrity and dependability. The QX offers three.

Limigard — now with BIST and FDA

Enhanced reliability for optimal plant operations and reduced troubleshooting costs are the primary benefits of Limitorque's patented smart actuator monitor, LimiGard.

When LimiGard wiring diagrams are followed, LimiGard continually monitors the motor controller, internal logic circuits and external command signals, comparing them to reference conditions. This virtually eliminates the possibility that an actuator malfunction can occur without prompt detection and alarm communication. In the event of a malfunction, LimiGard takes over and supervises the actuator's response characteristics, maximizing safety and predictability.

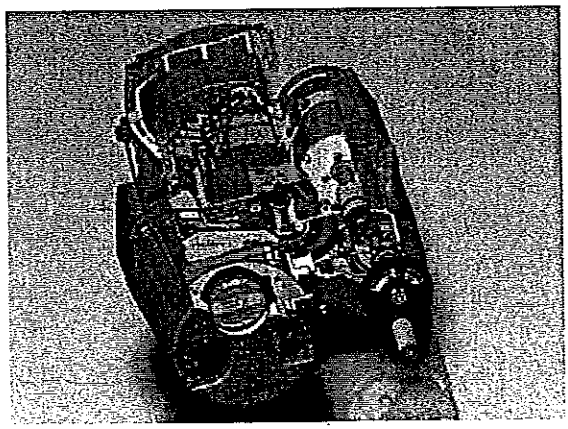
A state-of-the-art electronic actuator, such as the QX, includes means for verifying and validating that its components are designed with built-in self-test (BIST) capabilities. Selecting the QX, which incorporates a high level of BIST, can contribute greatly to the integrity and reliability of process applications and enhance the ability of a safety system to achieve its highest possible SIL rating.



Absolute position encoder

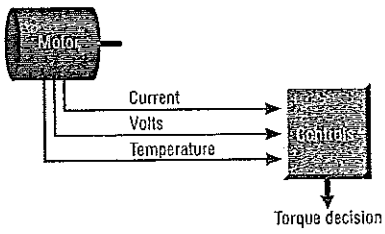
Limitorque patented the use of absolute encoders in smart electronic actuators. An absolute encoder simplifies valve automation from configuration and setup into normal operations, diagnostics and troubleshooting. The QX encoder employs system-on-chip technology using a contactless magnet that excites Hall-effect devices to provide redundant, 12-bit resolution over 360 degrees. This redundancy, part of the BIST features, means the device can continue to function reliably until a number of faults have been accumulated.

As the actuator turns, a mechanical coupling rotates the magnet about an array of several Hall-effect devices. When the magnet passes over a Hall-effect device, it causes a change in the electromagnetic field, and a digital signature (on-off) is developed. This signature is duplicated across the array of Hall-effect devices at specifically timed intervals, resulting in digital values that calculate the position of the valve via the electronic actuator.



Torque sensing

Torque limiting has been a Limitorque feature for better than 75 years. In fact, the name Limitorque was coined to identify the ability of an electric actuator to "limit torque" to a valve. In the past, electromechanical actuators have sensed torque using a complicated system of springs, switches and cams. The QX senses torque electronically for use in valve control, overload protection and torque trending. In conjunction with the Limigard feature, torque is sensed from motor current, with compensation performed for voltage and temperature variations. The result is highly reliable and predictable torque sensing without the need for the extra components associated with electromechanical torque switches. The QX is a true smart actuator.



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QX Control, Indication, Protection and Optional Features

Standard features

- Direct-wired remote control – Wiring flexibility includes the following standard alternatives to open-stop-close the actuator:
  - Four-wire – Valve can be opened, closed or stopped.
  - Two-wire switched – Single open or closed contact; valve can be opened or closed but not stopped.
  - Three-wire maintained – Two momentary contacts for self-maintained control. Valve can be opened or closed but not stopped in mid-travel.
  - Three-wire inching – Two "push-to-run" contacts; valve can be opened, closed and stopped in mid-travel.
- Multi-mode Control – Three modes of remote control are permitted when the QX is configured for multi-control: digital (discrete) control, analog control or network (fieldbus) control. The QX will respond to the last command received. However, analong (mondutronic) control is initiated by either toggling QX User Input 2 (configured for CSE input) or removing and reapplying the 4-20 mA analong signal. Refer to LMENTB2300 for further information.
- Monitor relay – Provides a N/O and N/C contact representing "Actuator available for remote operation."
- Emergency Shutdown (ESD) – Up to three remote, external ESD signals may be applied to the actuator to move the valve to a predetermined, user-configured shutdown position, overriding existing control signals.
- User-defined inputs – Three user-defined inputs are supplied.
- Inhibit signals – External signals may be used to inhibit actuator opening, closing or both.
- Control signals – The control signal can be either 24 VDC or optional 110 VAC; it can be sourced from the actuator or customer supply.
- Status contacts (two pairs) – May be set to represent up to 25 actuator conditions.
- Alternate speeds – The QX can be configured to permit differing speeds for Open or Close direction.

Protection features

- Autophase protection and correction – Ensures proper open/close directions and monitors and corrects phasing if connected improperly. Prevents operation if a phase is lost.
- Jammed valve – Automatically initiates a forward/reverse cycle to free jammed valves.
- Instantaneous reversal protection – Incorporates a time delay between the motor reversals to reduce current surges.
- Motor thermal protection – A thermistor, placed within the motor, protects against overheating.
- LimiGard™ circuit protection – QX actuators include LimiGard circuit protection. LimiGard consists of dedicated circuitry that continually monitors the motor controller, control relays, internal logic circuits and external command signals. When the recommended wiring connections are made, it virtually eliminates unexpected, erroneous actuation caused by internal electronic failures and erratic external command signals. Additionally, in the event of malfunction, LimiGard supervises the actuator response, detects the source of the failure and signals an alarm.

Optional features

- Alarm contacts – Up to eight latched contacts may be set to represent up to 25 key actuator conditions.
- Two-speed timer – A two-speed pulsing timer may be incorporated to support variable stroke times as configured by the user.
- Analog Position Transmitter (APT) – The APT is an internally powered, non-contacting valve position transmitter that provides a 4-20 mA signal proportional to valve position.
- Analog Torque Transmitter (ATT) – The ATT is a non-contacting, internally powered transmitter that provides a 4-20 mA signal that is proportional to actuator output torque.
- Modutronic controller – The Modutronic controller positions the valve in response to an external 4-20 mA command signal. It includes automatic pulsing mode to prevent overshoot at the set point. Parameters that may be set easily during configuration include proportional band, dead band, polarity and action on loss of command signal.
- QXH – The QX can be configured for modulating operation that requires greater than 600 starts per hour. It is available for up to 1200 starts per hour.
- Partial stroke and momentary closure ESD – The QX can be supplied with the ability to perform a partial stroke operational parameter. The partial stroke and momentary closure ESD signals are configurable by the user. It can also be supplied with a momentary closure contact initiated ESD signal routine with redundant circuitry.
- Control Station (CSE) – The CSE is a separate control station designed for the operation of inaccessible actuators. It is available with LEDs, Remote/Local and Open/Close selector switches. The CSE may be powered by the actuator's internal supply, provided wire resistance and other external loads do not limit the available signal power presented to the QX.

- Isolation and Load Break Switches – Isolation and Load Break Switches can be supplied for the incoming voltage supply to the actuator. These may be coupled directly to the actuator for weatherproof (WP) applications only or supplied separately for mounting by user. The enclosure is suitable for weatherproof or temporary submersion service. An explosion-proof (XP) isolation switch is also available for user mounting and is suitable for mounting with all QX actuators. Please contact factory for availability.
- Negative Switching – When remote control systems require the negative pole of the circuit supply to be switched to positive earth, a simple software change is made.
- QX Quik – After the actuator has been powered by line power for one hour, it will automatically withstand most power outages while maintaining the correct state of the Status and Alarm (S or R) contacts—even if the user repositions the actuator manually with the handwheel. To maximize its self-power time while the line power is lost, the actuator places itself in its lowest possible power usage mode. The LCD will darken (sleep mode) until it is activated for viewing. The LCD can be activated by moving the black knob to OPEN (YES) or by moving the actuator with the handwheel. After seven to eight seconds of inactivity, the LCD will return to sleep mode.

Bluetooth-capable options

Standard low-power wireless communication path to the actuator enables monitoring and configuration of the unit up to 10m in any direction via a Bluetooth-equipped PC, PDA, smart cell phone, etc. FHSS (Frequency Hopping Spread Spectrum) allows a reliable communication link even in a "noisy" environment and 128-bit data encryption can be enabled to protect the privacy of the link. QX Dashboard configuration / diagnostic tools can use the Bluetooth link as a means for communicating with the actuator. A visible blue LED in the control's LCD window on the face of the actuator signifies an active Bluetooth link to the actuator has been established.

Network Communications

The QX provides a comprehensive network option portfolio to the user. Network solutions are improved with the addition of DeviceNet to complement Modbus, Foundation Fieldbus H1, Profibus DP_V1 and Profibus PA. The QX provides the user with predictable, reliable and safe operation for years to come, in applications that are subject to the most rigorous requirements and environmental extremes.

DDC (Distributed Digital Control) Modbus communication

DDC is Flowserve Limitorque's digital communication control system that provides the ability to control and monitor up to 250 actuators over a single twisted-pair cable. The communication network employs Modbus protocol on an RS-485 network and is redundant. Redundancy ensures that any single break or short in the communication cable will not disable any actuators. Each actuator has included an addressable field unit that communicates over the twisted-pair network and executes open, close, stop, ESD and GO TO position commands. The field unit also communicates all actuator status and alarm diagnostic messages over the same communication network.

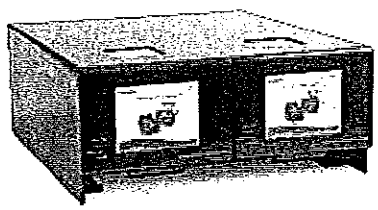
DDC Network

- Single-ended loop (consult factory)
- Modbus protocol
- High speed – up to 19.2 k baud

Master Station III

QX units equipped with DDC can be controlled via Flowserve Limitorque's Master Station III. It includes:

- Host interface – Industry standard Modbus Rtu, ASCI, UDP, and TCP/IP protocols and control
- 5.6" TFT touch-screen display for network configuration status
- Configurable polling sequence priority
- Network time protocol for time synchronization of alarms/diagnostics data to host device
- Modular hot-swappable redundant design
- E-mail notifications of alarm conditions
- Data/event logging



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FOUNDATION Fieldbus communication

The QX can be fitted with FOUNDATION Fieldbus protocol that complies with the IEC 61158-2 Fieldbus H1 standard. The field unit device is able to support several topologies such as point-to-point, bus with spurs, daisy chain, tree or a combination of these. The FF device has network features that include:

- Link Active Scheduler that controls the system
- High-speed communications up to 31.25 kbits/sec
- Publisher-subscriber communication
- Input and output function blocks
- Device descriptions
- Network communication
- Configurable by user

Link Active Scheduler communication: Fieldbus segments have one active Link Active Scheduler (LAS) at a given time, which is the bus arbiter, and does the following:

  - Recognizes and adds new devices to the link
  - Removes non-responsive devices from the link
  - Schedules control activity in, and communication activity between, devices
  - Regularly polls devices for process data
  - Distributes a priority-driven token to devices for unscheduled transmissions

PROFIBUS DP V1 communication with DTM (Device Tool Manager)

The QX can be fitted with Profibus DP_V1 protocol field units that comply with EN50170 Fieldbus Standard for RS-485 communications. The device supports several topologies such as point-to-point, bus with spurs, daisy chain, tree or a combination of these. The PB device has network features that include:

- High-speed communications up to 1.5 Mbps
- Master-to-slave communication
- Standby communication channel
- Analog and digital input and output function blocks
- Device descriptions configurable by user
- High-Speed Data Exchange – Startup Sequence
- Power On / Reset – Power On / Reset of master or slave
- Parameterization – download of parameters into field device (selected during configuration by the user)
- I/O Configuration – download of I/O configuration into the field device (selected during configuration by the user)
- Data Exchange – cyclic data exchange (I/O Data) and field device reports diagnostics

PROFIBUS PA communication with DTM (Device Tool Manager)

A Profibus PA protocol is available and complies with EN50170 Fieldbus Standard and Fieldbus physical layer per IEC 61158-2 for communications. The device supports several topologies such as point-to-point, bus with spurs, daisy chain, tree or a combination of these. The PB device has network features that include:

- High-speed communications up to 31.25 kbits/s with Manchester coding
- Master-to-slave communication
- Bus powered for 9-32 VDC and 15 mA per actuator
- Standby communication channel
- Analog and digital input and output function blocks
- Device descriptions
- Configurable by user

The Profibus DP-V1/PA DTM V 1.0 is a software component that contains device-specific application information. The DTM can be integrated into engineering and FDT frame applications, such as stand-alone commissioning tools or asset management systems that are equipped with FDT interfaces. FDT technology is independent from any specific communication protocol, device software or host system, allowing any device to be accessed from any DCS host through any protocol.

DeviceNet

DeviceNet complies with CAN-based protocol and provides the following features:

- DeviceNet Group 2 Server Implementation
- Master-to-slave communication
- Bus-powered network interface allows power alarm information to be communicated when actuator loses main power; the actuator does NOT drop off the network when power is lost
- Standard polled I/O connection
- Standard bit strobed I/O connection
- Standard change of state / cyclic I/O connection
- Standard explicit connections defined as:
  - Various assembly objects and sizes that allow the network user to determine how much data to transfer to accommodate network installation data throughput requirements
  - Automatic baud rate detection
  - Node address configurable via local setup menu or via the remote network user
  - Broadcast or group network originated ESD support

QX1 - QX5 Performance Ratings

Description	QX-1	QX-2	QX-3	QX-4	QX-5
Minimum Operating Time (sec)	5	8	15	30	60
Maximum Operating Time (sec)	20	30	60	120	120
Rated Seating Torque: seating (ft-lb/Nm)	100/136	250/339	400/542	750/1017	1500/2033
Seating Torque Limited by Base	Not Applicable	07 base 200 ft-lb (271 Nm) max	Not Applicable	Not Applicable	12 base 1000 ft-lb (1356 Nm) max
Run Torque: 20% (ft-lb/Nm)	20/27	50/68	80/108	150/203	300/407
Run Torque 50% (ft-lb/Nm)	50/68	125/169	NA	NA	NA
Stall Torque (ft-lb/Nm)	200/271	500/677	800/1083	1500/2031	3000/4063
Motor Seating Rating (in-lb/Nm) 1ph & 3ph	5/.56	12/1.36	5/.56	12/1.36	12/1.36
Motor Run Rating (in-lb/Nm) 1ph & 3ph	1/.11	2.4/.27	1/.11	2.4/.27	2.4/.27
Motor Stall Rating (in-lb/Nm) 1ph & 3ph	6.5/.73	15.6/1.76	6.5/.73	15.6/1.76	15.6/1.76
Gear Ratio Motorized	985	985	3662	3662	7212
Gear Ratio Handwheel	200	200	276	276	276
Handwheel Efficiency	26%	26%	26%	26%	26%
Handwheel Diameter (in/mm)	3/76	3/76	7.5/190	7.5/190	7.5/190
Handwheel turns for 90°	50	50	70	70	70
Handwheel Shaft Octagon Interface to Handwheel (in/mm)	.77/19.5	.77/19.5	.77/19.5	.77/19.5	.77/19.5
Handwheel Shaft Hex Drive (in/mm)	.63/16	.63/16	.63/16	.63/16	.63/16
MSS SP-101 Base FA/ISO 5211 Base F	05, 07, 10	07, 10	10/12/14	12/14	12/14
Max Diameter Bore & Square Key (inches)	05 Base Ø.875, 3/16 sq 07 Base Ø1.1875, 1/4 sq 10 Base Ø1.625, 3/8 sq	07 Base Ø1.1875, 1/4 sq 10 Base Ø1.625, 3/8 sq	10 Base Ø1.625, 3/8 sq 12 & 14 Base Ø2.375, 5/8 sq	12 & 14 Base Ø2.375, 5/8 sq	12 & 14 Base Ø2.375, 5/8 sq
Max Diameter Bore & Rectangular Key (inches)	05 Base Ø.93, 3/16 X 1/8 07 Base Ø1.25, 1/4 X 3/16 10 Base Ø1.75, 3/8 X 1/4	07 Base Ø1.25, 1/4 X 3/16 10 Base Ø1.75, 3/8 X 1/4	10 Base Ø1.875, 1/2 X 3/8 sq 12 & 14 Base Ø2.50, 5/8 X 7/16	12 & 14 Base Ø2.50, 5/8 X 7/16	12 & 14 Base Ø2.50, 5/8 X 7/16
Max Diameter Bore & Key (mm)	05 Base Ø22, 6 sq 07 Base Ø30, 8 X 7 10 Base Ø42, 12 X 8	07 Base Ø30, 8 X 7 10 Base Ø42, 12 X 8	10 Base Ø50, 14 X 9 12 & 14 Base Ø64, 18 X 11	12 & 14 Base Ø64, 18 X 11	12 & 14 Base Ø64, 18 X 11
Max Square Drive	05 Base 0.75 in sq, 19 mm sq 07 Base 1 in sq, 25 mm sq 10 Base 1.41 in sq, 35 mm sq	07 Base 1 in sq, 25 mm sq 10 Base 1.41 in sq, 35 mm sq	10 Base 1.625 in sq, 42 mm sq 12 & 14 Base 1.75 in sq, 45 mm sq	12 & 14 Base 1.75 in sq, 45 mm sq	12 & 14 Base 1.75 in sq, 45 mm sq
Max Double 'D' Diameter (in/mm)	05 Base Ø1.06 in/27 mm 07 Base Ø1.44 in/36 mm 10 Base Ø2.00 in/50 mm	07 Base Ø1.44 in/36 mm 10 Base Ø2.00 in/50 mm	07 Base Ø2.25 in/58 mm 12 & 14 Base Ø2.50 in/64 mm	12 & 14 Base Ø2.50 in/64 mm	12 & 14 Base Ø2.50 in/64 mm
Weight (lb)	40	42	80	80	80
Coatings	Primed using high solids epoxy-ecoat and powder topcoated, royal blue with a DFT of 1–3 mils. The coating is suitable for an ASTM B117 salt spray test of 1500 hours. Standard external fasteners are stainless steel.				

Information on base torque limits
05 base is limited to 100 ft-lbs max
07 base is limited to 200 ft-lbs max
10 base is limited to 400 ft-lbs max
12 base is limited to 1000 ft-lbs max

FLOWSERVE

QX Standard Features

The Flowserve Limitorque QX quarter-turn, smart electronic valve actuator is designed for the reliable operation of either ON-OFF or modulating quarter-turn valves. It includes a brushless DCV motor as standard, which can auto-correct to accept any global input voltage, single- or three-phase AC, or DC, an absolute encoder, electronic torque sensing, complete electronic control including a motor control board, state-of-the-art protection, control and monitoring features, mechanical gear reduction including worm gear as final output drive, declutch mechanism and handwheel for manual operation, valve interface bushing, 32-character LCD, local and remote control switches, built-in self-test (BIST) features and LimiGard fault protection. These features are all contained in a non-intrusive enclosure that is double-sealed to NEMA 4, 4X, 6, IP68 to 20M for 168 hours (and explosion-proof as required).

Power transmission and lubrication

All mechanical gearing components are bearing supported, and final drive (output) consists of a hardened alloy steel worm and alloy worm gear. All gears are immersed in an oil-bath lubricated with a synthetic oil designed specifically for extreme pressure worm and worm gear transmission service.

LUBRICATION & TEMPERATURE RANGE	SYNTHETIC BRAND
Standard Lubrication, -30°C to +70°C	Petro-Canada SHB 68 or Mobil SHC 626
Optional Food Grade Lubrication, -30°C to +70°C	Dow Molykote

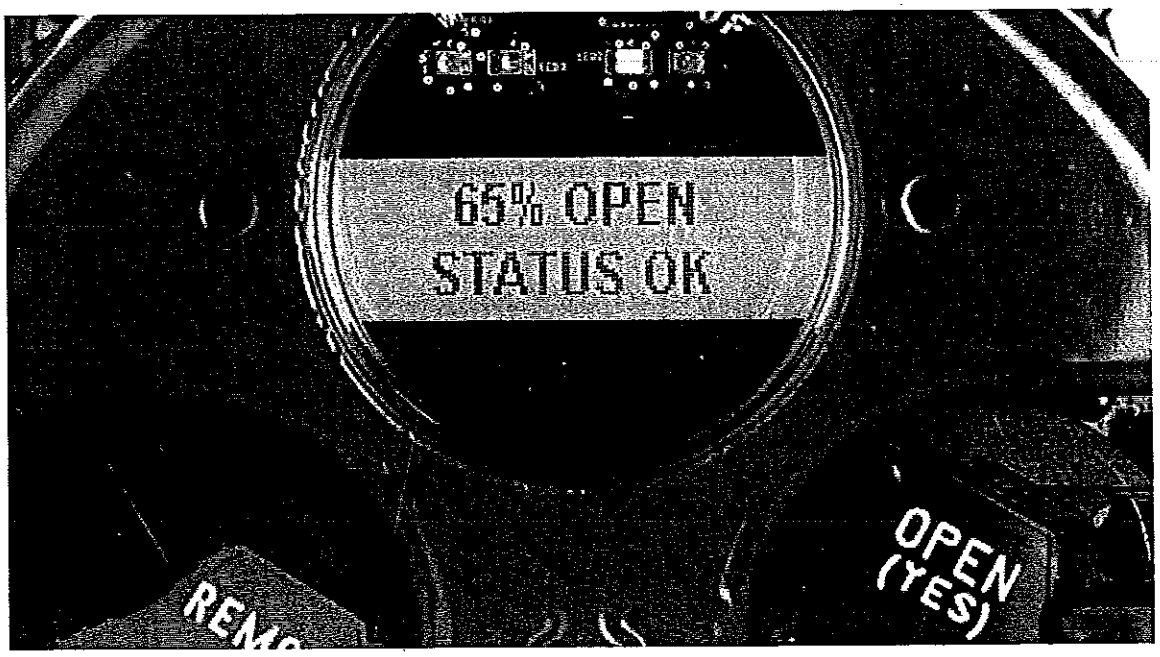
Motor

The QX motor is unique to quarter-turn electronic valve actuators. It is a brushless DC motor specifically designed for the QX actuator and complies with IEC 34, S2-50 percent duty cycle at 50 percent of rated torque. The motor is a true bolt-on design with a quick-disconnect plug that can be changed rapidly without sacrificing motor leads. It is equipped with a solid-state motor thermistor to prevent damage due to temperature overloads.

ON-OFF MODULATING
Standard insulation class is F to IEC 34, S2-50% for stated operating times 100-600 starts per hour
600-1200 starts per hour, IEC 34, S4_33%_1200 S/H

The QX motor permits a global range of voltages (single-phase and three-phase ACV and DCV) to be connected without modification. The motor can energize, provided either of the listed voltages are connected:

Phase/Frequency	Application Voltage
VDC	24-48
1ph – 60 Hz	110, 115, 120, 240
1ph – 50 Hz	220-250
3ph - 60 Hz	208, 220, 230, 240, 380, 440, 460, 480, 550, 575, 600
3ph - 50 Hz	380, 400, 415, 440, 525



Electronic control modules

Non-Intrusive
The QX is non-intrusive, which means that all calibration/ configuration is possible without removing any covers and without the use of any special tools. All calibration is performed in clear text languages; no icons are used. All configuration is performed by answering the "YES" and "NO" questions displayed on the LCD. "YES" is signaled by using the OPEN switch and "NO" by using the CLOSE switch, as indicated adjacent to the switches.

Double-sealed terminal compartment and terminal block
All customer connections are located in a terminal chamber that is separately sealed from all other actuator components. Site wiring doesn't expose actuator components to the environment. The internal sealing within the terminal chamber is suitable for NEMA 4, 6, and IP68 to 20M for 168 hours. The terminal block includes screw-type terminals; three for power and 54 for control. Customer connections are made via conduits located in the terminal housing.

Three Standard Conduit Openings (NPT threads standard, M optional)
(3) – 1.0" NPT (standard) or M25 (optional)
Optional Fourth Conduit Opening (NPT or M)
(1) – 1.25" NPT or M32

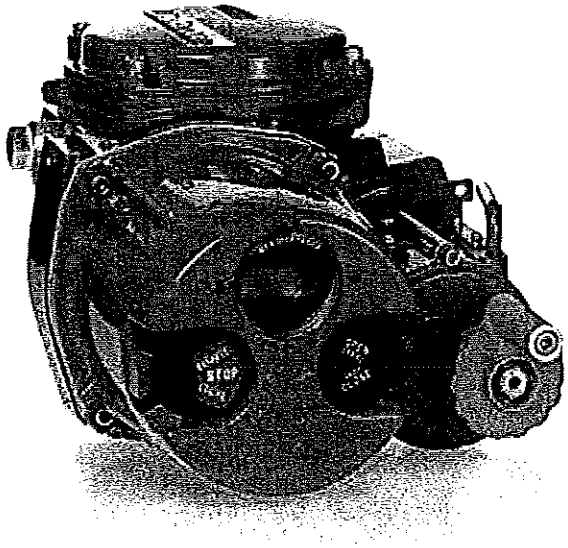
Controls
The controls are all solid state and include power and logic circuit boards and a motor controller that performs as the motor reverser, all mounted to a steel plate and attached in the control compartment with captive screws. All internal wiring is flame resistant, rated 105°C, and UL/CSA listed.

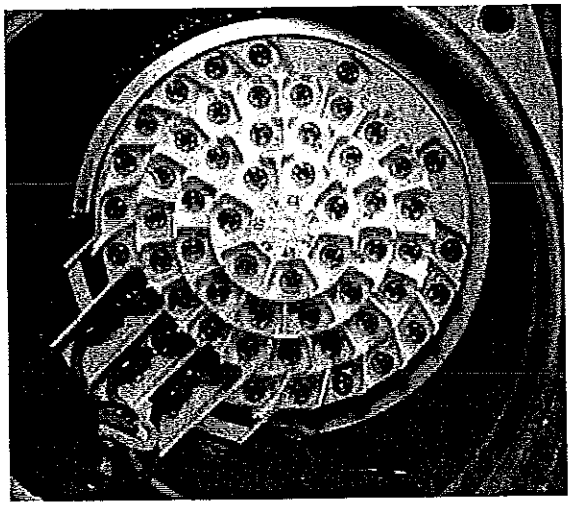
The controls are housed in the ACP (Actuator Control Panel) cover, and the logic module uses solid-state Hall-effect devices for local communication and configuration. A 32-character, graphical LCD is included to display valve position as a percent of open, 0-100% and current actuator status. Red and green LEDs are included to signal 'Opened' and 'Closed,' and are reversible, and a yellow LED to indicate 'Valve Moving.' A blue LED is included when the Bluetooth option is ordered. A padlockable LOCAL-STOP-REMOTE switch and an OPEN-CLOSE switch are included for local valve actuator control

Using the knobs and LCD screen the QX is configurable in 10 languages: English, Spanish, French, German, Portuguese, Italian, Mandarin, Russian, Bahasa Indonesia and Katakana.

S contacts for remote indication
As standard, two pairs of latched status contacts rated 125 VAC, 0.5 A and 30 VDC, 2 A are provided for remote indication of valve position, configured as 1-N/O and 1-N/C for both the open and closed positions. Two contacts may be configured to represent any other actuator status and the other two will be complementary. The contacts may be configured in any of the selections depicted in the "Actuator Status Message"column.

"S" Contact AC	"S" Contact DC
0.5 Amps @ 125 VAC	2A @ 30 VDC (Resistive)





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Actuator Status Message	Function
"CLOSED"	– valve closed "(0% OPEN)"
"OPENED"	– valve open "(100% OPEN)"
"CLOSING"	– valve closing
"OPENING"	– valve opening
"STOPPED"	– valve stopped in mid-travel
"VALVE MOVING"	– either direction
"LOCAL SELECTED"	– red selector knob in "LOCAL"
"MOTOR OVERTEMP"	– thermistor range exceeded
"OVERTORQUE"	– torque exceeded in mid-travel
"MANUAL OVERRIDE"	– actuator moved by handwheel
"VALVE JAMMED"	– valve can't move
"CLOSE TORQUE SW"	– torque switch trip at "CLOSED"
"OPEN TORQUE SW"	– torque switch trip at "OPEN"
"LOCAL STOP/OFF"	– red selector knob at "STOP"
"LOST PHASE"	– one or more of the incoming supply lost
"ESD SIGNAL"	– signal active
"CLOSE INHIBIT"	– close inhibit signal active
"OPEN INHIBIT"	– open inhibit signal active
"ANALOG IP LOST"	– 4-20 mA not present
"REMOTE SELECTED"	– red selector in "REMOTE"
"HARDWARE FAILURE"	– indication
"NETWORK CONTROLLED"	– permits relay control via DDC, FF, or other network driver
"FUNCTION"	– LimiGuard circuit protection activated
"MID-TRAVEL"	– valve position, 1-99% open
"CSE CONTROL"	– CSE station in LOCAL or STOP and controls actuator

Monitor relay for remote indication

A monitor relay is included as standard and trips when the actuator is not available for remote operation. Both N/O and N/C contacts are included, rated 125 VAC, 0.5 A and 30 VDC, 2 A. The monitor relay can be configured for three additional fault indications: lost phase, valve jammed and motor Overtemp. The yellow LED will blink when the monitor relay is active. The user can disable the monitor relay, if necessary.

Monitor Relay AC	Monitor Relay DC
0.5 Amps @ 125 VAC	2A @ 30 VDC (Resistive)

Remote control

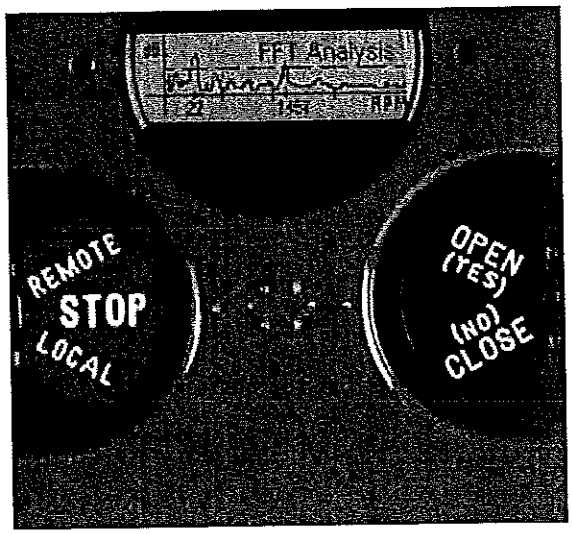
Discrete remote control (user supplied) may be configured as two, three or four wires for Open-Stop-Close control. Remote control functions may be powered by external 24 VDC, 110 VAC, or the actuator's internal 24 VDC supply or optional 110 Vac supply. The internal supplies are protected against over current and short circuit faults and utilize optical isolation to minimize electromagnetic interference. Discrete control provides isolated commons for up to three selections.

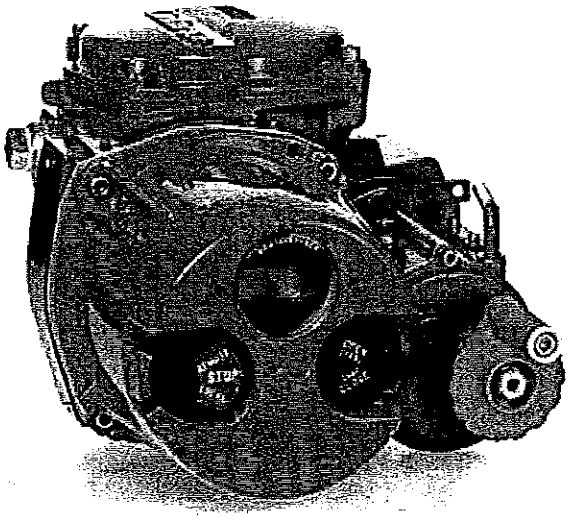
Signal Threshold for Voltage Values	Maximum Load
5.0 VAC/VDC maximum 'OFF'	24 VDC + 2 mA
19.2 VAC/VDC minimum 'ON'	110 VAC + 10 mA

Speed control

The QX permits operational speeds in either Open and Closed directions to be set independently of each other. The QX also has an industry leading span for the optional two-speed timer.

Speed Minimum (Open to Close)	Speed Maximum (Open to Close)	Two-Speed Timer Span "ON" Pulse	Two-Speed Timer Span "Off" Pulse
QX-1 = 5 seconds	QX-1 = 20 seconds	0.5 to 20 seconds (0.5 sec. increments)	1.0 to 200 seconds (1.0 sec. increments)
QX-2 = 8 seconds	QX-2 = 30 seconds	0.5 to 20 seconds (0.5 sec. increments)	1.0 to 200 seconds (1.0 sec. increments)
QX-3 = 15 seconds	QX-3 = 60 seconds	0.5 to 20 seconds (0.5 sec. increments)	1.0 to 200 seconds (1.0 sec. increments)
QX-4 = 30 seconds	QX-4 = 120 seconds	0.5 to 20 seconds (0.5 sec. increments)	1.0 to 200 seconds (1.0 sec. increments)
QX-5 = 60 seconds	QX-5 = 120 seconds	0.5 to 20 seconds (0.5 sec. increments)	1.0 to 200 seconds (1.0 sec. increments)





Software

Limigard

A dedicated circuit to prevent undesired valve operation in the event of an internal circuit fault or erratic command signal is included as standard on each Limitorque electronic actuator. A single point failure will not result in erratic actuator movement nor will an open or short circuit in the internal circuit board logic energize the motor controller. The command inputs are optically coupled and require a valid signal pulse width from at least 250 ms to 350 ms to either turn on or off. In the event of an internal circuit fault, an alarm is signaled by tripping the monitor relay and through LCD indication. The control module also includes an auto reversal delay to inhibit high-current surges caused by rapid motor reversals.

Phase detection and correction (three phase)

A phase correction circuit is included to correct motor rotation faults caused by incorrect site wiring or phase switching in the event of a power down. The phase correction circuit also detects the loss of a phase and disables operation to prevent motor damage. The monitor relay will trip and an error message is displayed on the LCD screen when loss of phase occurs.

Multi-mode remote control

The QX is capable of being configured for multi-mode remote control, which permits discrete wiring for either two, three or four wires, or network (Fieldbuses) for Open-Stop-Close control and responds to the last signal received. The actuator can also distinguish analog control for modulating applications. The QX and MX products from Limitorque are the only smart actuators with such features.

ESD

An Emergency Shutdown (ESD) provision is included in each actuator, and the QX has up to three configurable inputs for ESD. The ESD signal(s) can be selected to override any existing signal and send the valve to its configured emergency position. Provision for an isolated common is standard.

Inhibits

The QX has as standard provisions for inhibit movement and also contains up to three configurable inputs. Provision for an isolated common is also standard.

Diagnostics

The QX contains similar diagnostic facilities as the MX. The values are included to accumulate and report the performance of the motor, encoder, motor controller, cycle time, handwheel operations, actuator ID, firmware revision and output turns. In addition, a torque profile of the reference baseline valve stroke and the last valve stroke is included. A feature for resetting the diagnostic odometer is also provided. All diagnostic information is displayed on the LCD and can be acquired over a network if Fieldbus options are purchased. The QX actuator has the ability for diagnostics information to be downloaded to a PC or PDA via both IRDA and Bluetooth ports using the Dashboard software.

Valve and actuator position sensing

Valve position is sensed by an absolute encoder, employing system-on-chip technology which uses a contactless magnet that excites Hall-effect devices and provides 12-bit resolution over 360 degrees. Each of the position-sensing circuits contains a B.I.S.T. (built-in self-test) feature and is redundant, permitting up to 50 percent fault tolerance before the position

is incorrectly reported. The BIST feature discerns which failures will signal a warning only and which require a warning plus safe shutdown of the actuator. Open and closed positions are stored in permanent, nonvolatile memory. The encoder measures valve position at all times, including both motor and handwheel operation, with or without power present, and without the use of a battery. The absolute encoder is capable of resolving down to 0.1 percent of output shaft position over 360 degrees.

Valve and actuator torque sensing

The QX and MX are the only electric actuators that sense torque electronically. The QX senses torque electronically from motor current. The torque can be adjusted from 40 to 100 percent of rating in 1 percent increments, and the motor is deenergized if the torque limit is exceeded. A boost function is included to prevent torque trip during initial valve unseating and during extreme arctic temperature operation (from 0°C down to -60°C). The QX monitors for "jammed valve" as a protection feature and initiates an automatic retry sequence if no movement occurs.

Exterior corrosion protection

The QX actuator is coated with as standard a polymer powder coat suitable for exposure to an ASTM B117 salt spray test of 1,500 hours. External fasteners are 300 series stainless steel. Optional coatings are available by contacting factory.

Manual operation

A handwheel and declutch lever are provided for manual operation. The handwheel is an engineered resin material and changing from motor to manual operation is accomplished by engaging the declutch lever. Energizing the motor returns the QX to motor operation. The lever is padlockable in either motor or manual operation. Optional configurations for handwheels are available by consulting the factory.

Handwheel Ratio	Turns to Close 90°	Handwheel Diameter	Handwheel Efficiency
QX-1/QX-2 = 200:1	50	3"/76 mm	26%
QX-3, QX-4, QX-5= 276:1	70	7.5"/191 mm	26%

Factory testing

Every QX actuator is factory tested to verify rated output torque, output speed, handwheel operation, local control, control power supply, valve jammed function, all customer inputs and outputs, motor current, motor thermistor, LCD and LED operation, direction of rotation, microprocessor checks and position-sensor checks. A report confirming successful completion of testing is included with the actuator. Special testing can also be performed by contacting the factory.

Design life and endurance testing

- Design Life – 10,000 Open-to-Close cycles is considered typical life expectancy under normal operating conditions in approved ambient working environments.
- Endurance – 250,000 collective cycles of two 90-degree turns (0-90° Open, 90-0° Closed) were performed on the QX for proof of design.
- AWWA C540-02 – "Standard for Power Actuating Devices for Valves and Sluice Gates" – 10,000 cycles with confirmation of specified torque and position accuracy.

Options

Lost power buffer and 24 VDC UPS

Terminals are included and can be used to optionally connect the electronic controls package, including display, to a backup 24 VDC power source. Another option is the QX Quik. Once the actuator has been powered by line power for one hour, it can automatically withstand most power outages while maintaining the correct state of the alarm and status contacts, even if the user repositions the actuator manually with the handwheel. To maximize its self-power time while the line power is lost, the actuator will place itself in its lowest possible power usage mode. The LCD will darken (sleep mode) until it is needed to be viewed. The LCD can be activated by moving the black knob to OPEN (YES) or by moving the actuator with the handwheel. After 7-8 seconds of inactivity, the LCD will return to sleep mode. This feature can last up to three hours and automatically recharges once main power is restored.

The use of batteries to perform this function is not required.

Analog Position Transmitter (APT)

A non-contacting, internally powered, electrically isolated position transmitter can be included to provide a 4-20 mA or 0-10 VDC signal that is proportional to valve position.

Analog Torque Transmitter (ATT)

A non-contacting, internally powered, electrically isolated torque transmitter can be included to provide a 4-20 mA or 0-10 VDC signal that is proportional to rated output torque.

FLOWSERVE

Standard hazardous global certifications

FM – Class I, Groups B, C & D, Div. 1 and Class II, Groups E, F and G, T6

T6 temperature classification is possible with operational times less than 15 min.

ATEX EExd IIB T6 ATEX II 2 G, CENELEC Norm EN50014 and EN50018

ATEX EExd IIC T6 ATEX II 2 G, CENELEC Norm EN50014 and EN50018

CSA – Class I, Groups B, C & D, Div. 1 and Class II, Groups E, F and G, T4

IEC - Exd IIB T6, IIB T6

IEC - Exd IIC T6, IIC T6

Geographic Locations	Explosionproof Classifications	Standard Temperature	Optional Temperature (1)	Optional Temperature (2)
USA to Factory Mutual (FM)	Class I, Groups B, C, & D, Div. 1, T4 and Class II, Groups E, F, & G, Div. 2, T4	-30°C to +70°C (-22°F to 156°F)	-40°C to +50°C (-40°F to 122°F)	-50°C to +40°C (-56°F to 104°F)
Canada to Canadian Standards Association (CSA)	Class I, Groups B, C, & D, Div. 1, T4 and Class II, Groups E, F, & G, Div. 2, T4	-30°C to +70°C (-22°F to 156°F)	-40°C to +50°C (-40°F to 122°F)	-50°C to +40°C (-56°F to 104°F)
ATEX II 2 G, CENELEC Norm EN 50014 & 50018	Eex d IIB T6, Eex d IIC T6, and Eex de IIB T6, Eex de IIC T6	-30°C to +70°C (-22°F to 156°F)	-40°C to +50°C (-40°F to 122°F)	-50°C to +40°C (-56°F to 104°F)
IEC (International Future)	Eexd IIB T6, Eexd IIC T6, and Eexde IIB T6, Eexde IIC T6	-30°C to +70°C (-22°F to 156°F)	-40°C to +50°C (-40°F to 122°F)	-50°C to +40°C (-56°F to 104°F)

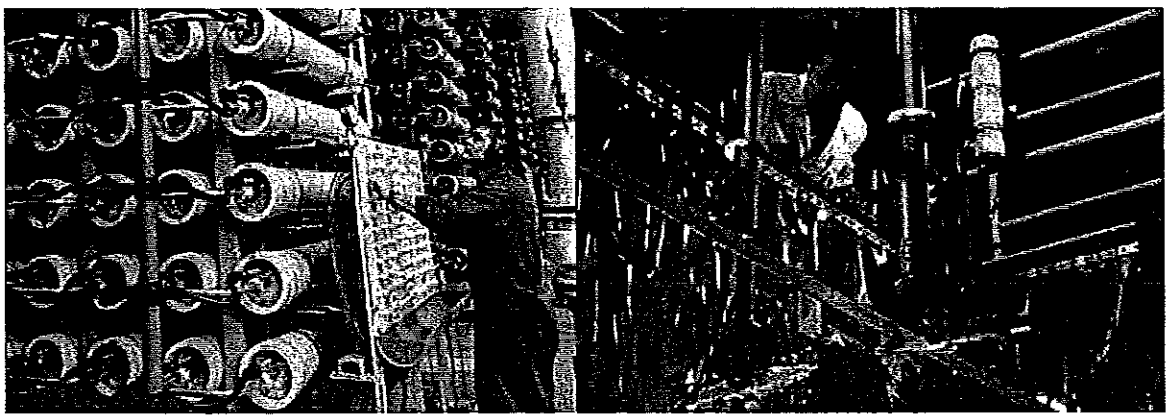
European directives

All QX actuator designs have been tested to demonstrate compatibility with the following European directives and are marked with the CE label:

- 89/392/EC - Machinery Directive
- Vibration and seismic capability is in accordance with MILSTD-167, IEEE-344-1975, and IEC68-2-6. Test performed in each of three (3) axes, H1, horizontal – parallel to motor, H2, horizontal – perpendicular to motor, and "V1," vertical.

Vibration Levels (QX functions after event)	Seismic Levels (QX functions after event)
5-100-5 Hz sweeps at 0.75g acceleration in 3 axes	5.0g acceleration from 3.5 – 31 - 3.5 Hz sine dwells in 3 axes
2-35-1 Hz sweeps at 1.0 g acceleration in 3 axes	3.0g acceleration from 35 - 200 Hz sine dwells in 3 axes
1-500-1 Hz sweeps @ 2.0 g acceleration in 3 axes	
25 Hz dwell @ 2.0 g acceleration in 3 axes	

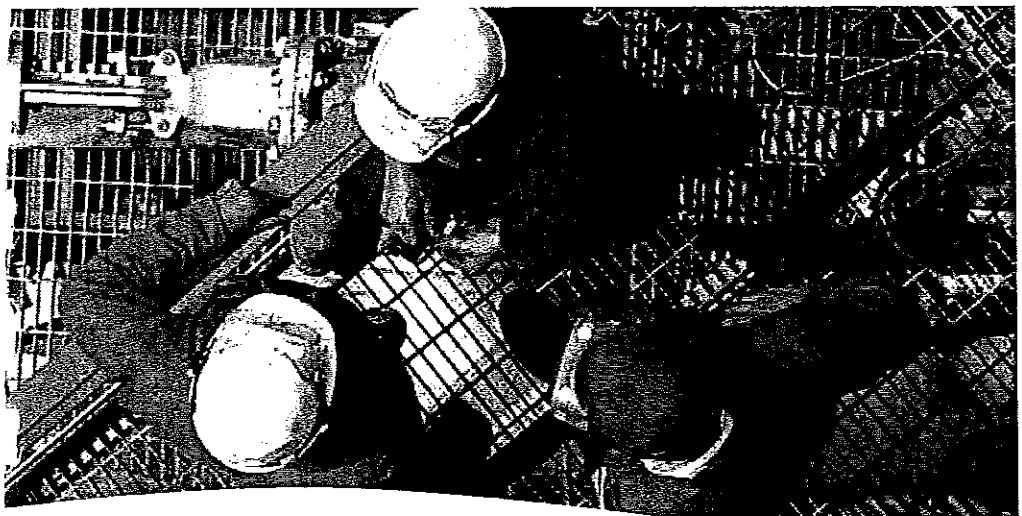
- Drop test – ASTM-D3332-88, method A
- 2003/10/EC -Airborne Noise to EN 60204-1
  The QX has been tested for noise emissions and at 1 m distance is less than 74 dB per grade A noise requirement of MIL-STD-740 and ANSI/ISA-S82.01-1994 (harmonized std. to IEC 1010-1).
- 2004/108/EC -EMC – Electromagnetic Compatibility and 93/68/EC -Low Voltage; EN 50081-1 & 2 – actuator complies with all pertinent requirements of Class A service categories in the listed table.



Applicable Emissions standards	EN50011:1998	Class A service
Radiated emissions	EN55011:1998 & FCC Part 15, subpart J	
		30-130MHz
		40dBmV / m
		230-1000MHz
		47dBmV / m
Conducted emissions	EN55011:1998 & FCC Part 15, subpart J	0.15 to 0.5MHz
		79dBmV (QuasiPeak
		66dBmV avg
		0.5 to 30MHz
		73dBmV (QuasiPeak
		60dBmV avg
Applicable Immunity standards	IEC EN 61000-6-1:2001	
ESD	IEC61000-4-1:1995	±8kV thru air
		±4kV thru contact
Radiated RF Immunity	IEC61000-4-3:1995	80MHz to 2GHz
		10Vrms / m
Fast transients/burst	IEC61000-4-4:1995	EFT
		AC Power leads: ±2kV
		Signal leads: ±1kV
Voltage surges	IEC61000-4-5:1995	
		AC Power: ±2kV com, ±1kV diff
		AC Power: ±2kV com, ±1kV diff
Conducted RF Immunity	IEC61000-4-6:1996	150kHz to 80MHz
		3-10Vrms
Magnetic field immunity	IEC61000-4-8:1993	Power line frequency
		30A/m @ 60Hz
Voltage dips and interrupts	IEC61000-4-11:1994	60Hz
		30%, 10ms dips
		60%, 100ms dips
		60%, 1s dips
		95% interrupt for 5s

• Di-electric – Motor per NEMA MG1-12.02 and .03 with leakage of less than 10 mA. Control terminals per IEC-1131-2 and CSA C22.2 with check against physical breakdown.

FLOWSERVE



FCD LMENBR3302-00 0409 Printed in USA.

To find your local Flowserve representative:

For more information about Flowserve Corporation, visit www.flowserve.com or www.limitorque.com, or call USA 1 800 225 6989

nqa. ISO 9001 Registered

ANAB ACCREDITED

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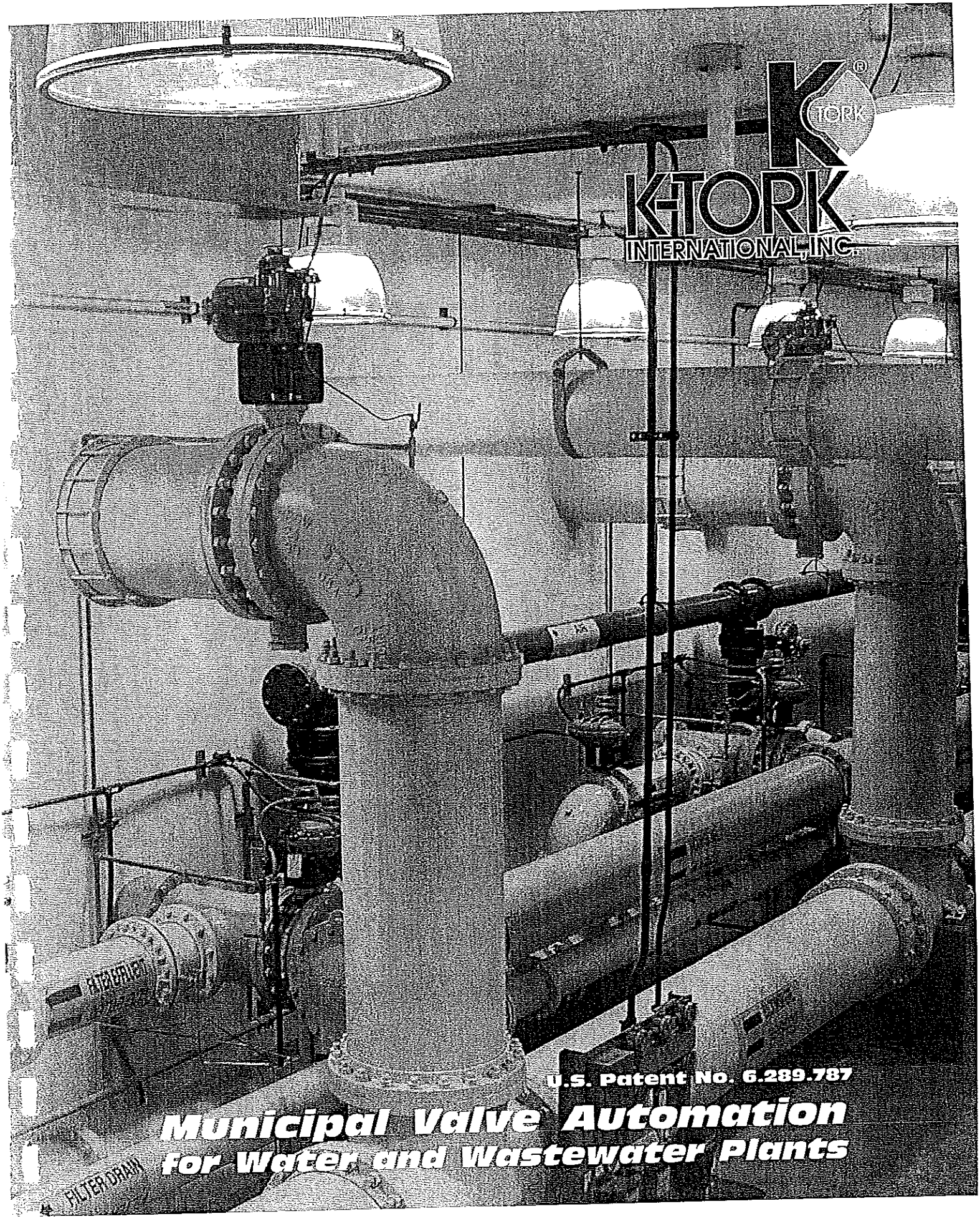

K-TORK
INTERNATIONAL, INC.
U.S. Patent No. 6,289,787
Municipal Valve Automation
for Water and Wastewater Plants

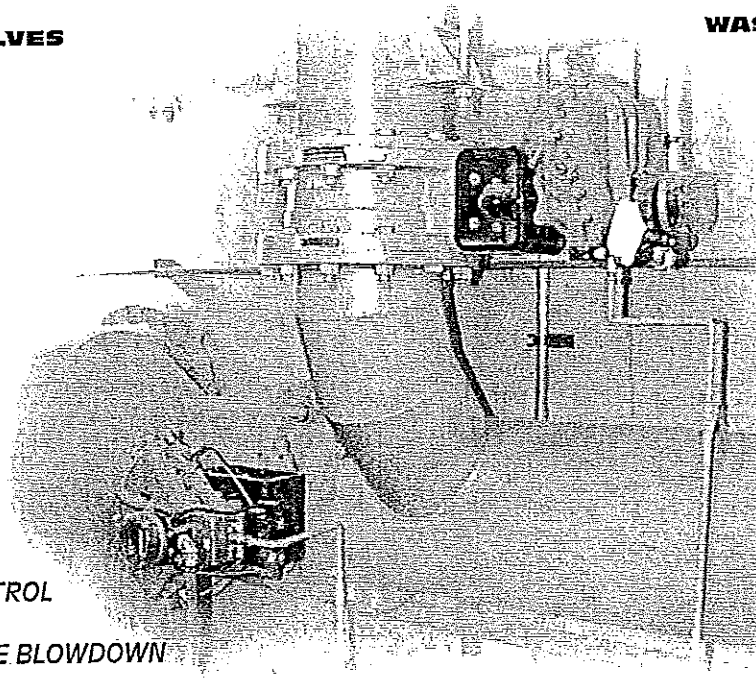
K-TORK
actuators & controls

K-TORK Rotary Vane Actuators

are designed for long life and precise control of 1/4-turn valves. With only one moving part, the simplistic design provides years of smooth and positive valve positioning.

WATER PLANT VALVES

- *INFLUENT*
- *EFFLUENT*
- *BACKWASH*
- *DRAIN*
- *SURFACE WASH*
- *AIR SCOUR*
- *FILTER-TO-WASTE*
- *LIME FEED*
- *RAW WATER CONTROL*
- *CLARIFIER SLUDGE BLOWDOWN*



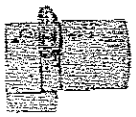
WASTEWATER PLANT VALVES

- *TERTIARY FILTER*
- *PUMP CONTROL*
- *SLUDGE BASIN BLOWER*
- *DIVERTER*
- *DAMPER DRIVE AIR CONTROL*
- *HIGH & LOW SERVICE PUMP CONTROL*

- Low friction: smooth operation, rated to 150 PSI working pressure, per AWWA C-540, Power Actuating Devices.
- Simple, single moving part, easy to troubleshoot.
- No cranks or gearing results in NO BACKLASH or "slop", and allows accurate positioning.
- Linear torque output. No torque loss at mid-stroke or side load to valve or actuator.
- Compact design fits into the tight confines of filter gallery or vault.
- Long maintenance-free life. 3-year Performance Warranty.
- Complete range of controls to interface with SCADA or filter control system.
- For use on butterfly, plug & ball valves, or any device requiring 100 degree or less rotation.
- Filter valves can FAIL-CLOSED, OPEN or LAST-POSITION upon loss of main power or control power.
- Totally enclosed. No dangerous external moving parts or pinch points.

K-TORK
actuators & controls

Control options are designed to mount in a simple, modular fashion to **K-TORK** *actuators*

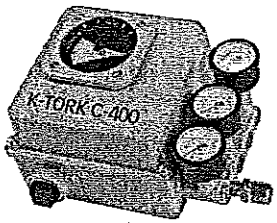


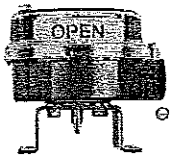
K-TORK I/P module to accept 4-20 mA input. Mounts inside positioner. Intrinsically safe. FM, CSA, & CENELEC Approved

K-TORK position transmitter module provides 4-20 mA output for remote indication of valve position

K-TORK limit switch module for end position feedback

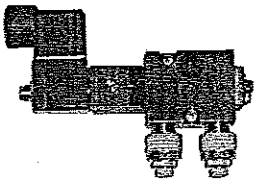
K-TORK
Positioner for modulating or throttling control. 3-15 PSI or various input signals available. Visual indicator and gauge set standard. All metal construction, field reversible.



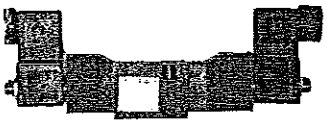


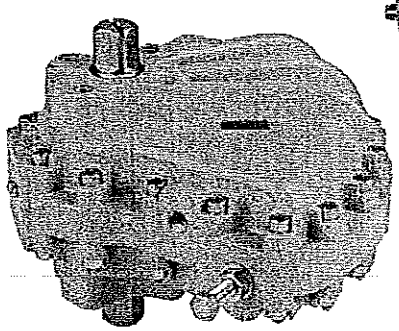
INFORMER™
Limit switch for hazardous areas, Class 1, Division 1 OR 2, explosion proof, visual valve position indicator, FM, CSA, CE, CENELEC Approved Mechanical, proximity and solid state contacts available

INFORMER™
Economical Weather Proof Limit Switch, NEMA 4X (IP65) rated. Visual valve position indicator.



SIDEWINDER™
Models #k-1 thru #K-4 accept the Namur Direct Mount Solenoid Valves. Both NEMA 4 (IP65) and explosion-proof hazardous area ratings. Manual override pushbutton

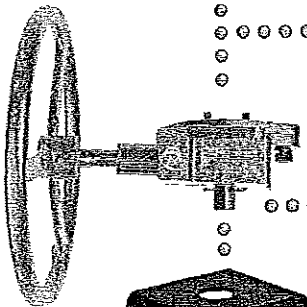




SIDEWINDER™ DUAL-COIL
Dual-Coil for "pulse" control. NEMA 4 (IP65) weather-proof rating. Manual override pushbuttons.

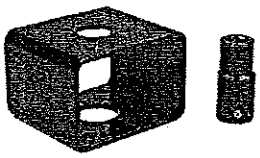
K-TORK vane actuator, 7 sizes up to 150,000 IN/LBs (16950 Nm) Adjustable rotation 80 to 100 degrees with restricted travel versions optional

I/P Converter
The Series XP-1000 I/P Converter is a compact, rugged instrument that is inherently insensitive to shock, vibration and mounting position. Always used with manual override regulator.



K-TORK
Declutchable gear manual override

Other Accessories:
- Speed Controls
- Air Filter Regulators
- Locking Devices



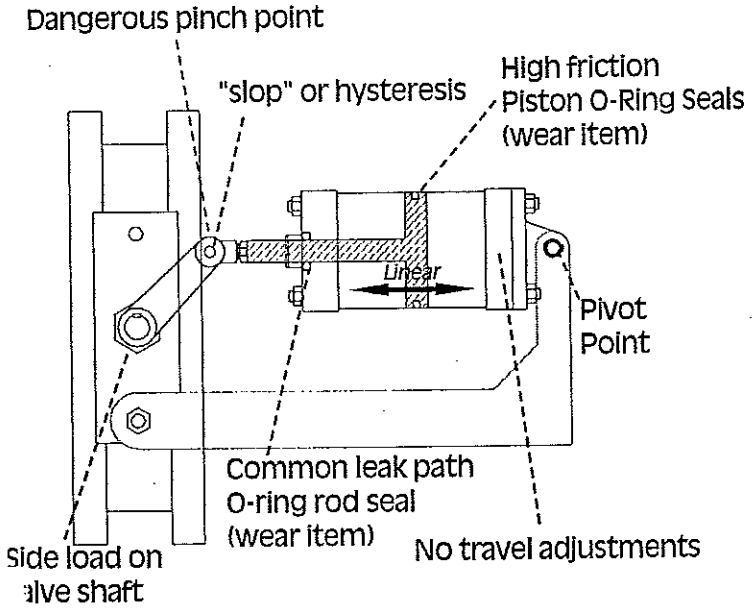
Linkage Kits to valves, new or existing, including Pratt, DeZurik, Keystone, CMB, BIF, Walworth, American-Darling, Alice Chalmers, Clow, M&H, Kennedy, Milliken, and others.

is a **True Rotary Actuator**:

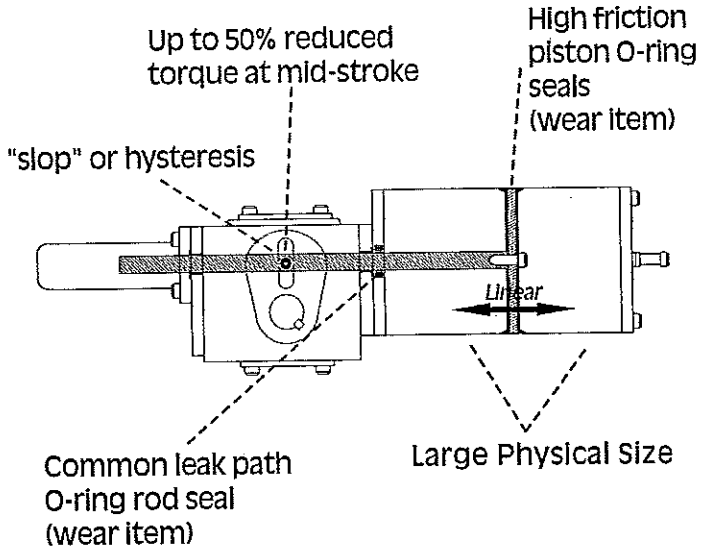
While traditional piston actuators convert **linear motion** *to rotary motion by means of cranks, gears or levers, the strength of* **K-TORK** *is its* **simplicity** *(one moving part - the vane) and* **NO O-RING SEAL** *design.*

Problems Associated With Other Designs:

iston Actuator Design



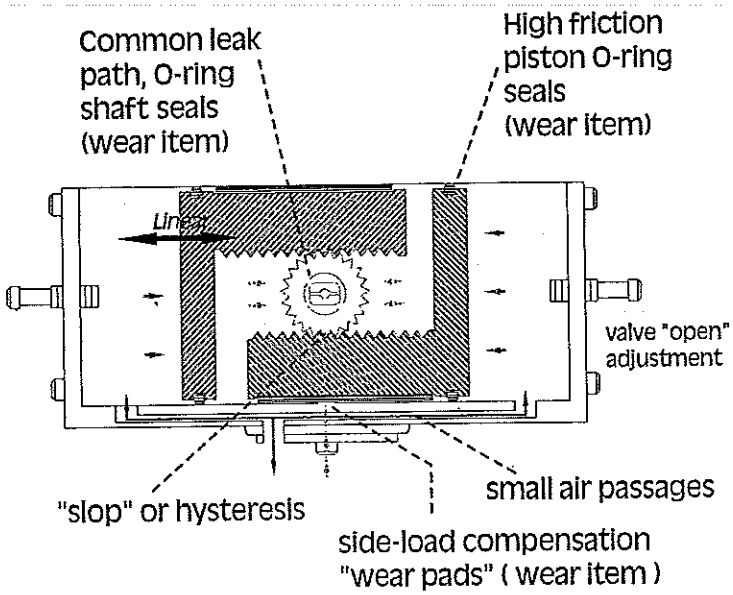
Scotch Yoke Actuator Design



ectric Actuator Design

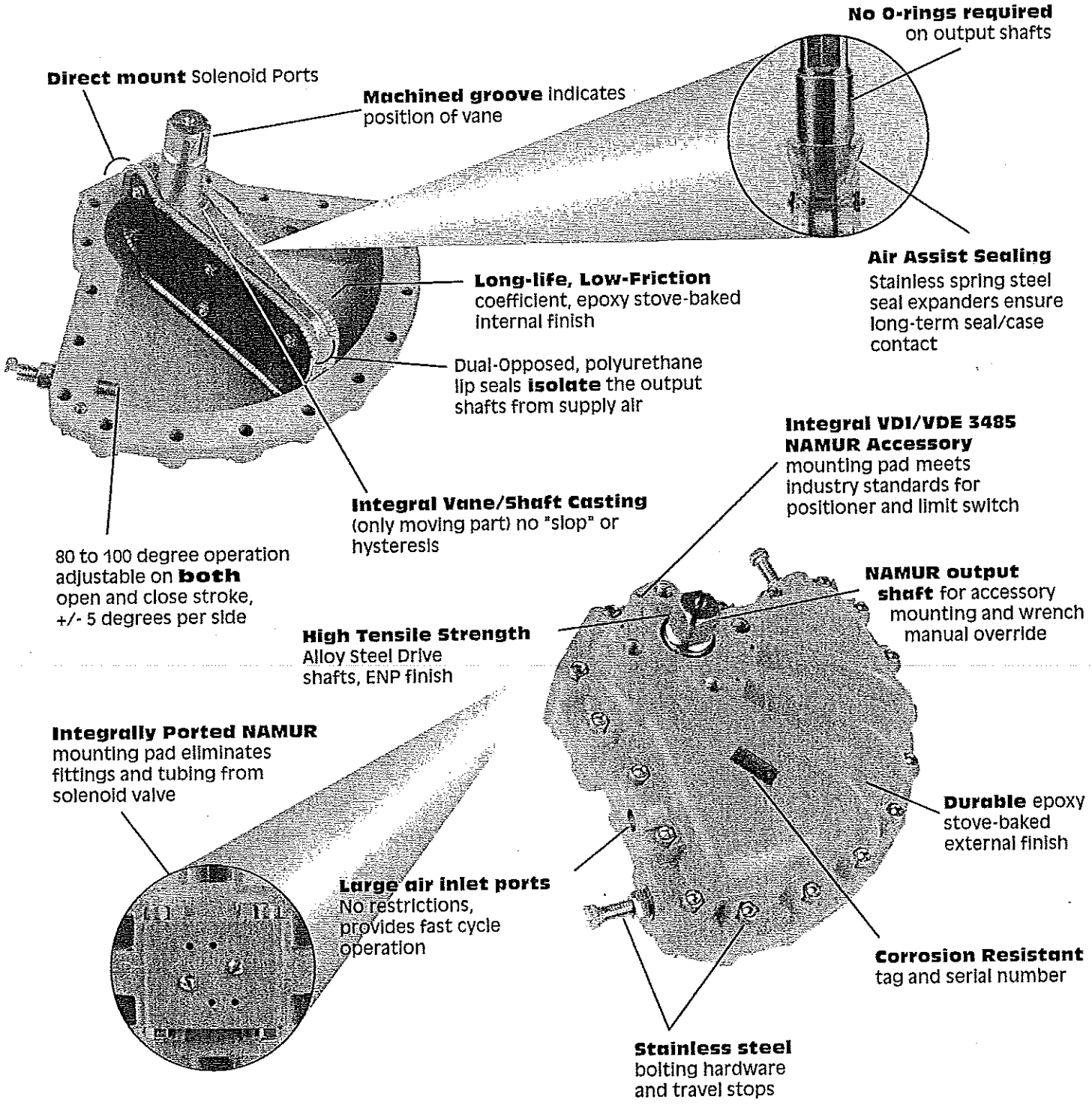
Feature	K-TORK ACTUATORS VS.	Electric Actuators
FAIL-SAFE	Can fail valves to CLOSED or OPEN position on loss of main, electric or control power.	Will fail in LAST POSITION, requiring manual operation to move to closed position.
SAFETY	DOES NOT require dangerous HIGH VOLTAGE.	Normally requires 230 / 460 VAC 3 phase power.
MAINTENANCE	Simple, reliable, only one moving part.	Many moving parts and circuit cards, complex and difficult to troubleshoot.
OUSEKEEPING	Does not require hydraulic oil or grease-filled enclosures.	Contain grease and lubrication that may leak.
OPERATING SPEED	Adjustable from 3 to 180 seconds.	Fixed speed, non-adjustable.
ERFORMANCE	Suitable for high-cycle operation, 100% duty cycle.	Limited to motor duty cycle and maximum number of starts per hour.
WARRANTY	3-YEAR PERFORMANCE WARRANTY, including parts and labor or free replacement.	1-YEAR WARRANTY, limited to materials and workmanship.

Rack & Pinion Actuator Design



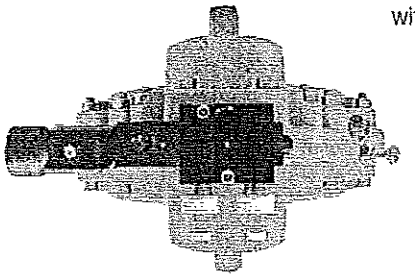
The K-TORK Advantage

K-TORK offers the solution for water and wastewater plants using outdated and typically non-performing, high maintenance, pneumatic or **hydraulic cylinder actuators.** Many believe that **electric actuators** are the only alternative, but soon find that *electric motor actuators* are complicated and *difficult* to troubleshoot, often requiring factory-trained personnel.



Solenoid Valves

K-TORK SIDEWINDER™ SOLENOID VALVES optimize actuator performance when mounted on to the K-TORK vane actuator. Models #K-1 through #K-4 accept the NAMUR mount version and models #K-5 through #K-7 utilize the bracket mount version. A standard adapter plate is supplied with all NAMUR units for both double-acting and spring-return applications.



- Readily accessible "Guarded-Push" turn to lock manual override
- HIGH FLOW FACTOR, Cv = 1.35 for fast operation
- Anodized Aluminum body, temperature rated -5F to 125F (-15C to 50C)
- FM, CSA, CE & UL Approved, NEMA 4 (IP65) and NEMA 7 (EEx e II T6), Cl. 1 / Div. 2 Hazardous Areas.
- Dual exhaust ports for INDEPENDENT speed control adjustments
- Interchangeable coil voltages include DC 12, 24 & 120 / AC 24, 120 & 220

Media
Lubricated or non-lubricated compressed air, instrument air or Nitrogen.

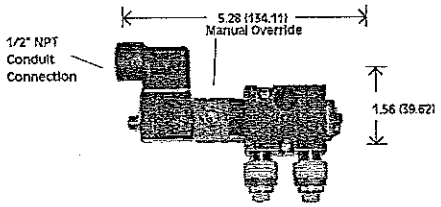
Pressure Range
28 PSI min. to 115 PSI (1.9 to 7.9 bar)

Construction

Body	Anodized Aluminum
Seals	NBR (Nitrile)
Ports	1/4" NPT
Conduit	1/2" NPT

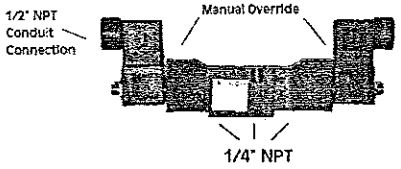
Power Consumption
2 Watts for DC and AC units
100% duty cycle

Single Coil



For Open-Close Control

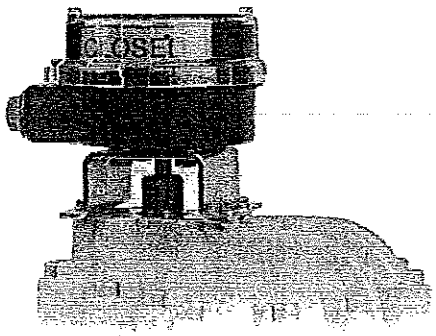
Dual Coil



For Pulse Control and Open-Close Control

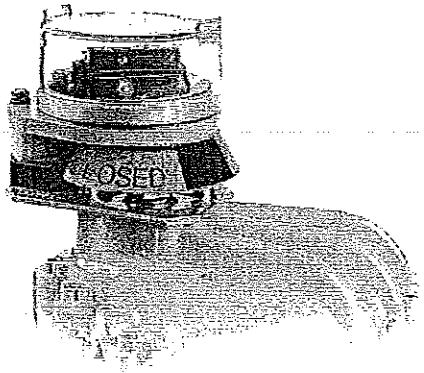
MODEL	MOUNTING	PROTECTION CLASS
#KSV-N-4-S-A120	NAMUR	IP65, NEMA 4 / 4X
#KSV-P-7-S-A120	REMOTE (side-ported)	IP65, NEMA 4 / 4X / 7
#KSV-P-4-D-A120	REMOTE (dual coil)	IP65, NEMA 4

Limit Switches

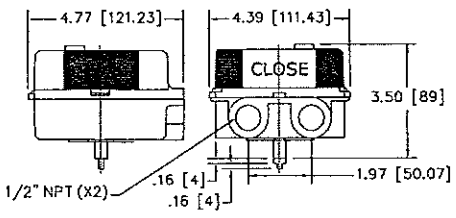


K-TORK INFORMER™ LIMIT SWITCHES offer a wide range of internal contacts and transmitters to interface with your control system. Housed in two basic enclosures, the INFORMER mounts directly to the K-TORK integral NAMUR pattern.

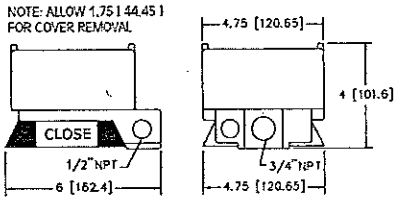
- All units include "OPEN – CLOSE" visual valve position indicator
- Economical NEMA 4/4X (IP65) version includes (2) SPDT mechanical contacts, INF-A
- Explosion-proof NEMA 4/4X/7 (EEx e II T6) version available with mechanical contacts or solid state contacts with LED indicators, suitable for all DC or AC voltages, INF-B
- All units include dual conduit entries and spare solenoid wiring terminals, labeled
- **"Touch and Tune"** switch settings allow adjustment in seconds without tools



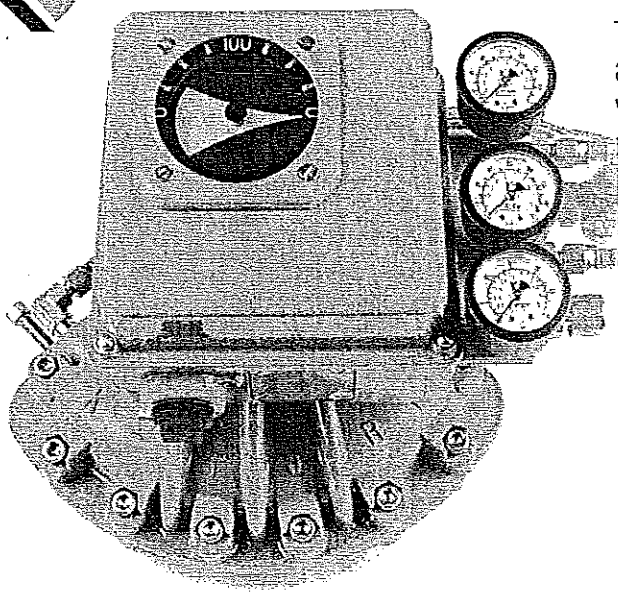
INF-A



INF-B



Control Valve Positioner



The **K-TORK C-400 Positioner** and actuator assembly enhances the performance of 1/4 turn control valves such as effluent, backwash, raw water inlet and rate of flow valves. Pneumatic, electro-pneumatic and intelligent digital units combine to provide high performance rotary valve control. Electro-pneumatic and digital "SMART" units are 2-wire loop powered.

- Internal option modules include I/P converter, position transmitter and limit switches
- Simple and reliable design, VDI/VDE 3845 NAMUR direct mount eliminates external levers, couplings and linkage for rotary applications
- Fast and accurate calibration, NON-INTERACTIVE Zero and Span adjustment reduces set-up time
- Immune to shock and vibration. FM, CSA, CE and CENELEC Approved
- Compact, rugged all-metal enclosure and internal working components – NO PLASTIC parts
- Standard with 0-100% flat visual indicator, gauge set, linear cam, equal percentage cam and quick opening cam included
- Single or reverse-acting, easily FIELD REVERSIBLE
- "SMART" Digital units and High Temperature units also available
- See Bulletin #CD-400 for details on the K-TORK "SMART" intelligent positioner, which includes HART® digital communication via 4-20 mA signal, easy pushbutton set-up with LED indication, auto-stroke calibration and characterized output curves. Microprocessor provides diagnostics and operating parameters

Temperature Range
-40F to 185F (-40C to 85C)

Enclosure
NEMA Type 4X / IP65
2-part, stove-baked epoxy finish
Captured stainless steel fasteners

Supply Pressure
35 to 150 PSIG (2.4 to 10 bar)

Supply Pressure Effect
<0.20% of span for 5 PSIG (34 bar) change in supply pressure

Flow Capacity at 60 PSIG (4.1 bar)

For #K-1, #K-2	4.5 scfm (Cv=0.15)
For #K-3, #K-4	9.0 scfm (Cv=0.30)
For #K-5, #K-6, #K-7	20.0 scfm (Cv=0.60)

Air Consumption at 60 PSIG (4.1 bar)

CP-400	0.5 scfm
CE-400	0.6 scfm

Input Signals

CP-400	3-15, 3-27, 6-30 PSIG 50% split range
CE-400	4-20 mA (30 VDC max.) 50% split range

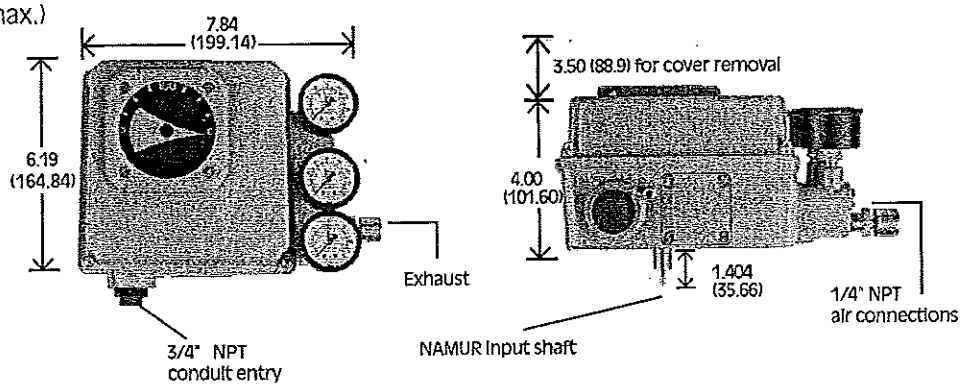
Output Configuration
Double or Single Acting

Action
Direct or Reverse

Connections
Pneumatic 1/4" NPT
Gauge 1/8" NPT
Electrical (conduit) 3/4" NPT
Exhaust 1/4" NPT w/breather

Visual Position Indicator
0-100% dial-type, reversible

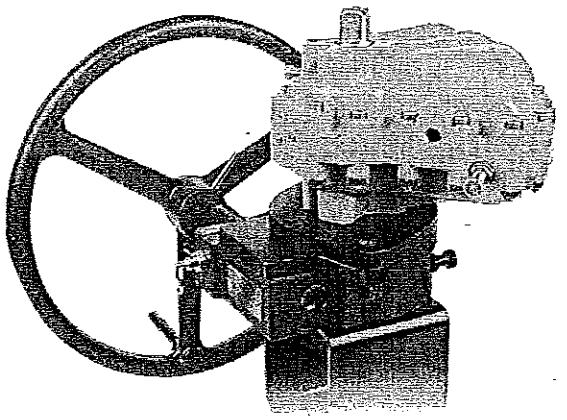
Performance Specifications	CP-400 Pneumatic	CE-400 Electro-Pneumatic
Linearity	0.50% of span	0.50% of span
Hysteresis	0.25% of span	0.30% of span
Repeatability	0.25% of span	0.40% of span
Deadband	0.25% of span	0.30% of span



Manual Overrides

K-TORK GEARED MANUAL OVERRIDE allow the user to operate their valve without air supply pressure. The gear mounts between the actuator and valve without the need for additional mounting kits.

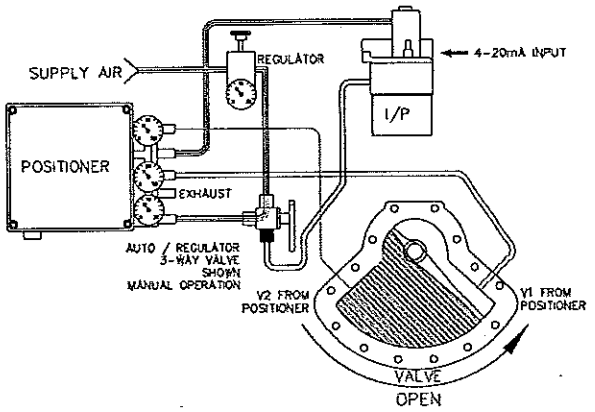
- Retrofit to existing **K-TORK** actuator with no modification to existing valve mounting hardware
- All units include two adjustable mechanical position stops and high temperature grease
- Actuator may be removed for maintenance while gear remains intact to operate valve
- Constructed from rugged cast iron with hardened steel worm that rides against a bronze sector gear



K-TORK ACTUATOR MODEL	K-TORK GEAR		RATIO	HANDWHEEL DIAMETER*	HAND WHEEL TURNS	WEIGHT LBS.(kg)
	MODEL NO.	TORQUE IN/LBS (Nm)				
K-1	K1-GB	2,400 (271)	24:1	8"std	6	17 (8)
K-2	K2-GB	2,400 (271)	24:1	8"std	6	17 (8)
K-3	K3-GB	8,196 (927)	32:1	16"std	8	48 (22)
K-4	K4-GB	13,992 (1,580)	40:1	16"std	10	65 (30)
K-5	K5-GB	36,000 (4,067)	64:1	24"std	16	127 (58)
K-6	K6-GB	75,000 (8,474)	282:1	16"std	70	182 (83)
K-7	K7-GB	150,000 (16,948)	860:1	16"std	215	366 (166)

*Alternate handwheel diameters available on application.

K-TORK PNEUMATIC MANUAL OVERRIDE allow the user to operate their modulating valve in "Manual Mode" with a precision regulator. The "Auto-Regulator" selector valve overrides and isolates the SCADA control system and allows the operator to infinitely position the valve locally.



Accessories

I/P Converter

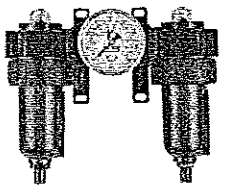
The Series XP-1000 I/P Converter is a compact, rugged instrument that is inherently insensitive to shock, vibration and mounting position. Always used with manual override regulator.

- 4-20 mA input / 3-15 PSI output
- Supply pressure 30 to 145 PSIG
- FM & CSA Approved Explosion-Proof and Intrinsically Safe
- Wide ambient operating temperature range, -40 to +180 Degrees F.
- No measurable influence from RFI-EMI effects
- Aluminum enclosure with epoxy finish

Speed Controls

K-TORK #K-EX-SC precision exhaust speed controls restrict and muffle the exhaust air from the actuator, providing adjustable, accurate and repeatable speed control.

- Independent OPEN & CLOSE adjustments
- Adjustable cycle times
  Model #K-1 through #K-3 = 5 to 90 seconds
  Model #K-4 through #K-7 = 10 to 180 seconds
- Available 1/4", 3/8" and 1/2"



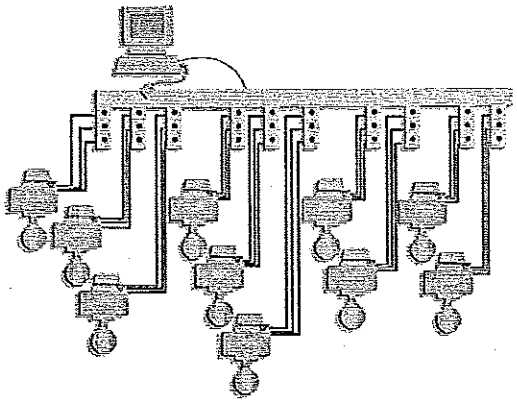
Combination Air Filter

K-TORK Combination Filter Assembly consists of a particulate upstream pre-filter and a coalescing downstream filter to ensure clean air to actuators and controls.

- Particulate filter rated to 5 micron particles
- Coalescing filter rated to 0.1 micron particles
- Available in 3/8" and 3/4" NPT
- Includes differential pressure indicator and gauge
- Rated to 250 PSI maximum supply pressure

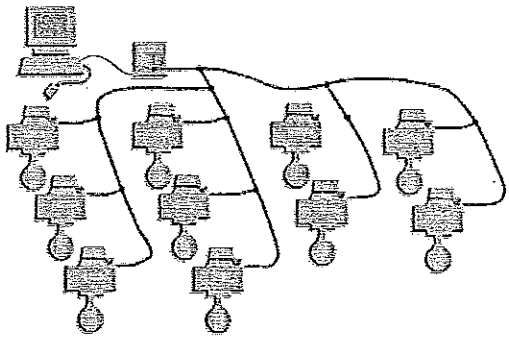
K-TORK *and* **StoneL Corporation** *have formed the* **FieldLink Alliance Partnership** *to supply standardized communication networks and intelligent valve controls to form Water and Wastewater Plant Intranets. These intelligent field networks reduce installation costs, cut commissioning time, reduce space requirements and enable valve and instrument diagnostics. Our scope includes actuator controls and all other devices required to integrate a successful 2-wire or 4-wire network.*

Contact **K-TORK** *for more information.*



Conventional System

Conventional valve wiring networks attach each of the inputs and outputs (I/O) to a central location resulting in multiple wire runs for each field device. Large expenditures are needed for cabling, conduit, installation and I/O points.



FieldLink Network

FieldLink Communication Networks are now available for use in interconnecting automated valves, instruments and other sensors in the plant environment. FieldLink products are designed to be installed today to interconnect discrete and analog valves and instrument networks together with SCADA, PC, DCS and PLC systems.

AS-i

DeviceNet™

Fieldbus Foundation

AS-i
(Actuator Sensor Interface)

The **AS-i** protocol networks up to 31 simple ON/OFF field devices onto a single pair of wires. The AS-i network is simple, reliable and field proven.

- Simple electronics for economical and robust performance. Reduced field wiring
- Transfer medium is unshielded two-wire cable for BOTH data and power supply
- Signal transmission has high tolerance to EMI
- Easy to install, providing the greatest cost savings with the least complexity
- Variety of gateways to seamlessly tie into high level bus networks, such as MODBUS (RS232C, RS422, RS485), MODBUS+, PROFIBUS (DP, FMS), DeviceNet and Ethernet (TCP/IP)

DeviceNet™ *

The DeviceNet protocol dramatically reduces costs by integrating up to 62 devices on a 4-wire trunk network. Both discrete and analog devices may be connected into the **DeviceNet™** protocol.

- Electronic Data Sheet provides on-line operating specifications
- Power and communication supplied over the 4-wire bus
- Hot insertion of field devices with out dropping power
- High noise immunity and wide temperature ranges

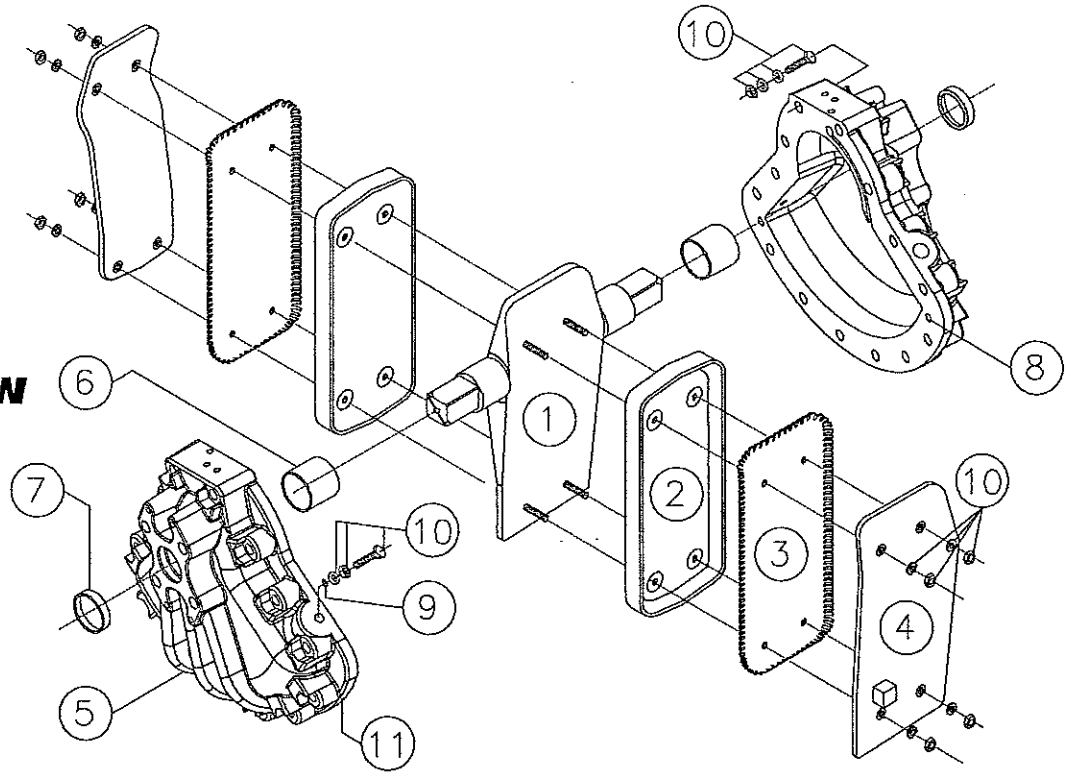
*DeviceNet ™ is a trademark of Open Vendor Association Inc.

Fieldbus Foundation

The Foundation Fieldbus H1 level has been designed as a digital replacement of the 4-20 mA standard in the process industries. Although ideal for analog devices, it may also be used for discrete devices.

- Typically from 2 to 16 devices may be included on a common network
- Provides greater controllability and process information
- Standardized function blocks, representing control I/O, speed, and set-up
- Long bus lengths and spur drops
- Supported by over 80% of the world's process instrumentation suppliers

Exploded View



Materials of Construction

ITEM	QTY.	DESCRIPTION	MATERIAL
1	1	Vane and Output Shaft	High Tensile alloy steel / Electroless Nickel Plated
2	2	Vane Seal	Polyurethane, 175 F (80 C) / K-Seal, 300 F (150 C)
3	2	Vane Seal Expander	Stainless Spring Steel
4	2	Vane Seal Side Plate	Carbon Steel, Epoxy Finish
5	2	Case Half	K-1 to K-4 A380 Aluminum / K-5 to K-7 A356 Aluminum
6	2	Shaft Bushing	Glacier DU
7	2	Shaft Seal	Nitrile, 175 F (80 C) / K-Seal, 300 F (150 C)
8	2	Locator Pin	Mild Steel
9	2	Stop Bolt O-ring	Nitrile, 175 F (80 C) / K-Seal, 300 F (150 C)
10	LOT	Hardware	Stainless Steel
11	LOT	Interior / Exterior Finish	Two-Stage Stoved Epoxy

SPEED OF OPERATION

MODEL	K-1	K-2	K-3	K-4	K-5	K-6	K-7
90Stroke	.10	.21	.50	1.19	2.44	5.50	11.01

Notes:
1. Times are in seconds
2. Tested with K-TORK Sidewinder solenoid valve, Cv=1.35
3. Supply air 80 PSI (5.5 bar) as tested
4. Cycle times tested with actuator driving 80% of rated torque at 80 PSI (5.5 bar)
5. Speeds adjustable up to 180 seconds on most models.

Working Temperature Range
Polyurethane -20F to 175F
(-30C to 80C)

Maximum Working Pressure *
150 PSI (10 bar)

Maximum Overload Pressure
225 PSI (15 bar)

* Per AWWA C-540, Power Actuating Devices

DISPLACED VOLUME, cu. in. (cu. cm)

MODEL	K-1	K-2	K-3	K-4	K-5	K-6	K-7
in^3	21	44	105	250	511	1153	2306
$(cm)^3$	(348)	(720)	(1720)	(4084)	(8393)	(18887)	(37774)

Notes: Volume of air required for one (1) 90 degree operation

ACTUATOR (DA) WEIGHTS

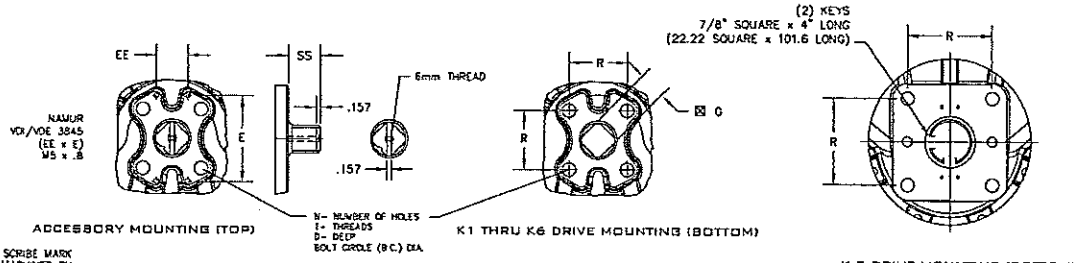
MODEL	K-1	K-2	K-3	K-4	K-5	K-6	K-7
lb	6.0	11.5	21.2	40.3	105	220	370
(kg)	(2.2)	(4.3)	(8.0)	(15.0)	(39.2)	(82.1)	(138.0)

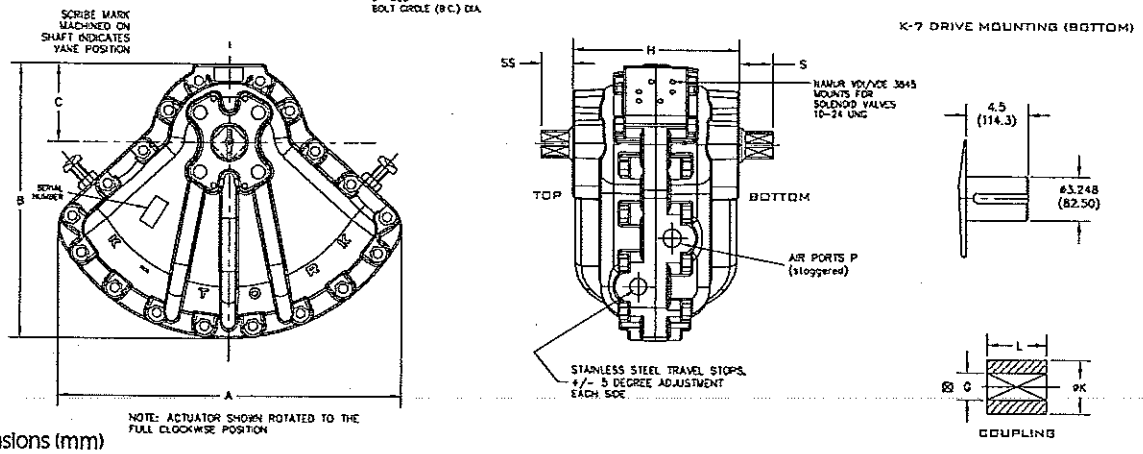
Double Acting Torque Output (inch-lbs.)

Model	Operating Pressure								
	40 PSI	50 PSI	60 PSI	70 PSI	80 PSI	90 PSI	100 PSI	125 PSI	150 PSI
K-1	384	492	600	720	840	960	1080	1344	1620
K-2	816	1044	1272	1524	1776	2016	2280	2844	3420
K-3	1860	2400	2892	3432	3960	4476	4992	6240	7488
K-4	4548	5796	6996	8292	9600	10800	12000	15000	18000
K-5	10596	13392	16092	18792	21600	24300	27000	33744	40500
K-6	22200	28296	34500	41292	48000	54492	60000	75000	90000
K-7	47500	60000	73000	86500	100000	111500	125000	155000	N/A

Dimensions (inches)

Model	A	B	C	E	EE	G	H	S	SS	N	T (UNC)	D	R	B.C.dia.	P(NPT)	K	L	Wt (lb)
K-1	8.02	6.43	1.95	3.15	1.18	0.63	3.94	0.76	0.79	4	5/16-18	0.62	1.42	2.00	1/4	1.25	1.57	6.0
K-2	9.88	8.08	2.37	3.15	1.18	0.75	4.95	1.03	0.79	4	3/8-16	0.75	1.80	2.55	1/4	1.50	1.97	11.5
K-3	12.61	10.04	2.80	3.15	1.18	0.98	6.15	1.22	1.18	4	1/2-13	0.94	2.16	3.06	3/8	2.00	2.22	21.2
K-4	16.35	12.91	3.60	3.15	1.18	1.12	7.88	1.50	1.18	4	5/8-11	1.80	2.75	3.89	1/2	2.25	2.50	40.3
K-5	22.48	17.86	5.41	3.15	1.18	1.61	10.84	2.18	1.18	4	7/8-9	2.00	4.25	6.01	1/2	3.38	3.54	105.0
K-6	28.49	22.92	6.70	5.12	1.18	2.24	14.20	2.94	1.97	4	1-1/8-7	2.00	6.30	8.91	1/2	5.00	5.13	220.0
K-7	30.11	23.73	7.15	5.12	1.18	N/A	22.45	N/A	1.97	4	1-1/8-7	2.00	6.30	8.91	3/4	4.53	N/A	370.0



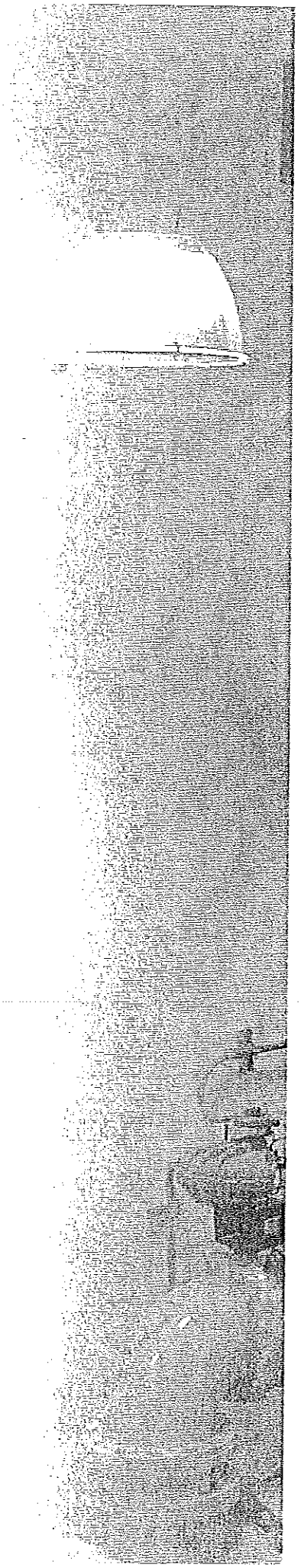


Dimensions (mm)

Model	A	B	C	E	EE	G	H	S	SS	N	T (ISO)	D	R	B.C.dia.	P (ISO)	K	L	Wt (kg)
K-1	203.7	163.2	49.4	80.0	30.0	16.0	100.0	19.3	20.1	4	M8	15.7	36.0	50.9	G 1/4	31.8	39.9	2.7
K-2	251.0	205.3	60.2	80.0	30.0	19.0	125.7	26.0	20.1	4	M10	19.1	45.7	64.7	G 1/4	38.1	50.0	5.2
K-3	320.0	255.0	71.0	80.0	30.0	24.9	156.2	30.9	30.0	4	M12	24.6	54.9	77.6	G 3/8	50.0	56.4	9.6
K-4	415.3	327.9	91.4	80.0	30.0	28.5	200.2	38.0	30.0	4	M16	31.8	69.9	98.8	G 1/2	56.7	63.5	18.3
K-5	571.0	453.5	137.4	80.0	30.0	40.9	275.3	55.3	30.0	4	M24	41.3	108.0	152.7	G 1/2	85.7	89.9	47.6
K-6	723.9	582.0	170.2	130.0	30.0	56.9	360.7	74.7	50.0	4	M30	50.8	160.0	226.3	G 1/2	127.0	133.3	99.8
K-7	764.9	602.7	181.6	130.0	30.0	N/A	570.2	N/A	50.0	4	M30	50.8	160.0	226.3	G 3/4	115.1	N/A	167.8

Double Acting Torque Output (Nm.)

Model	Operating Pressure							
	3 Bar	4 Bar	5 Bar	6 Bar	7 Bar	8 Bar	9 Bar	10 Bar
K-1	47	65	84	104	123	141	157	176
K-2	101	138	179	219	261	298	335	373
K-3	231	315	402	488	572	654	736	818
K-4	563	763	974	1179	1376	1573	1769	1966
K-5	1308	1757	2203	2654	3097	3539	3981	4424
K-6	2750	3758	4856	5938	6882	7865	8849	9832
K-7	5900	7900	10100	12150	14200	16400	18300	N/A



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Made in the U.S.A.

Information in this publication is believed to be accurate. K-TORK reserves the right to modify published information to reflect product improvements or changes. Please contact K-TORK if certified data is required. Products sold and licensed by K-TORK are covered by the warranty appearing in its standard terms and conditions of sale.

ISO 9001 Accredited

Catalog # KT-MUN-ACT, Revision 0, 04/06

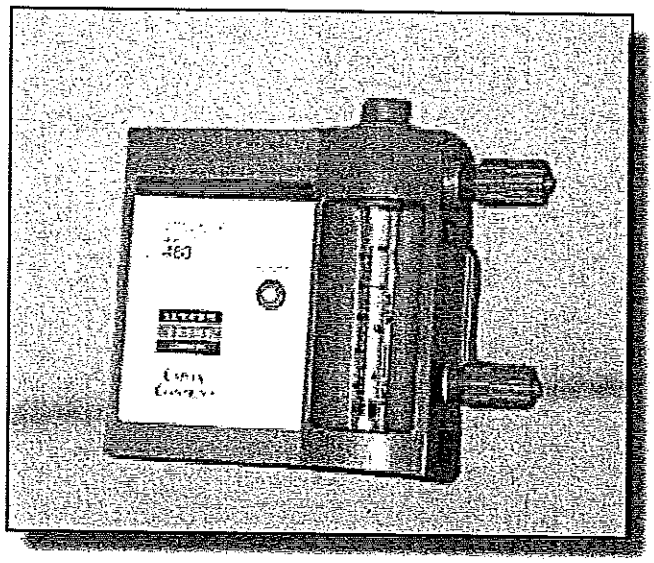
APPENDIX D

GAS CHLORINATOR INFORMATION

SEVERN TRENT SERVICES

Disinfection Products

CAPITAL CONTROLS®
ADVANCE™ Gas Chlorinator Model 480



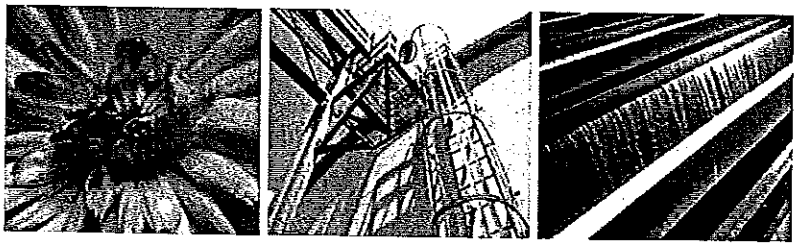
Severn Trent Services developed the all-vacuum gas feeders which have become the worldwide standard.

Model 480 gas chlorinators are designed for manual or semi-automatic gas regulation.

Easy to install, for indoor or outdoor installation, each Model 480 chlorinator is factory tested and needs no field adjustment prior to start-up. Five different flowmeter capacities provide versatility in meeting gas flow requirements. Chlorinators mount directly on the gas valve of a cylinder utilizing a lead gasketed positive yoke clamp. Diaphragm ejectors are standard with a choice of diffuser outlets. As an option, a variety of different ejectors are available to meet your application needs.

A Model 480 chlorinator consists of a vacuum regulator, ejector or chemical induction unit and vacuum and vent tubing to make a complete system. If multiple feed points are required, remote meter panels and additional ejectors are provided. A switchover module is offered to provide for uninterrupted service.

- Safe and reliable all-vacuum operation
- Worldwide standard for chlorinator technology
- Superior materials of construction for wet or dry gas service
- Safe integral venting system
- Five capacities up to 100 PPD (2 kg/h)
- Solid silver rate and inlet valves
- Direct cylinder mounted
- Replaceable inlet capsule
- Remote metering available
- Optional switchover capability with automatic reset for uninterrupted service



CHEMICAL INDUCTION UNITS

Severn Trent Services CHLOR-A-VAC® Series 1420 chemical induction units offer improved chlorination and dechlorination through the high-efficiency mixing of gaseous chemical with process water. This translates into operating and chemical cost savings.

CHLOR-A-VAC® units produce a vacuum when process water passes through water inlet ports and through a venturi. The high vacuum and recessed impeller create great turbulence and complete chemical mixing.

A chemical induction unit in lieu of an ejector should be considered for the following applications: contact basins, headwater, return sludge processes, clarifier inlets, collection basins, equalization tanks and clear wells. (Refer to Bulletin 130.0001)

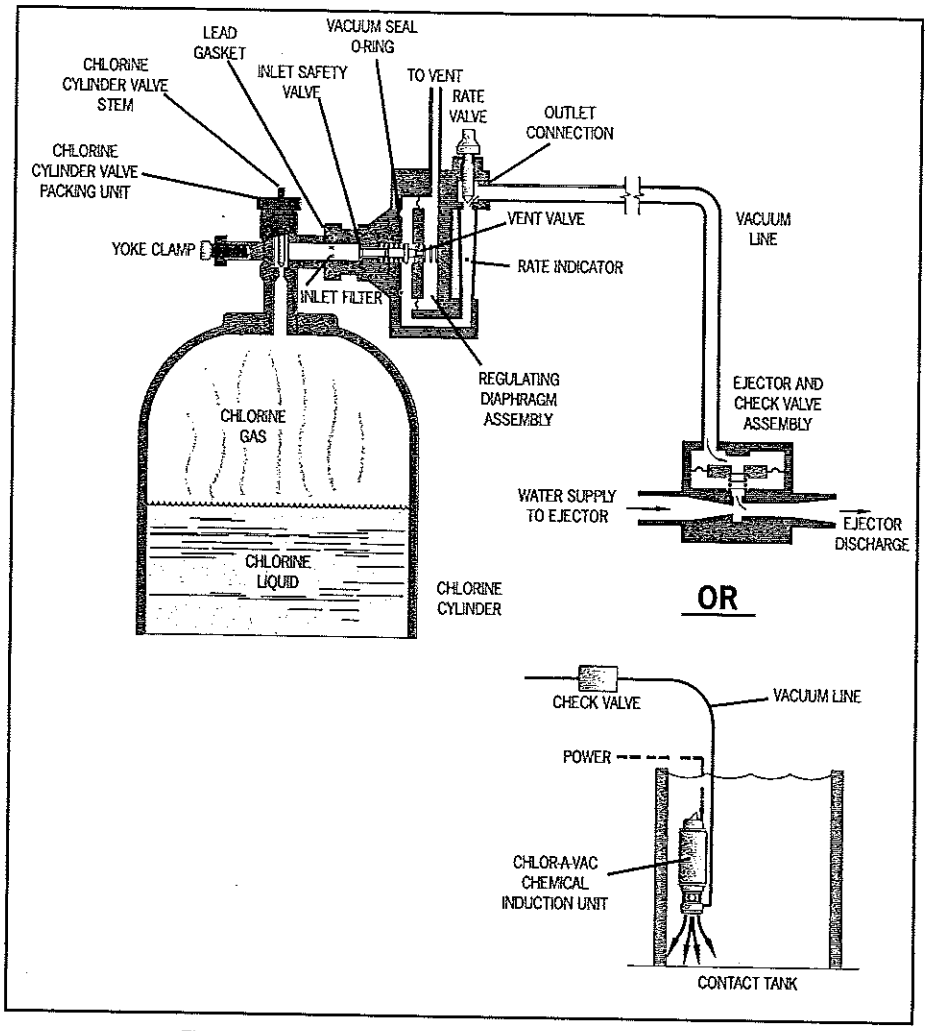


Figure 1 - Cylinder Mounted Chlorinator Flow Diagram

DESIGN FEATURES

- Sonic Flow: Gas flows at sonic velocity maintaining constant gas flow; additional pressure regulation is not required.
- Automatic Switchover: A separate, independent device that does not require manual reset. Flow indication is available at both vacuum regulators. Each vacuum regulator has a separate independent vent and an integral pressure relief device.
- Reliable: Over 35 years of experience with all vacuum operation, loss of chlorine supply indicator, integral venting system, double-thickness main regulating diaphragm, integral gas flow indicator.
- Ease of maintenance: Simplicity of design and modularized components; such as the replaceable inlet capsule for minimized maintenance.
- Superior materials of construction: Solid silver rate valve, corrosion resistant yoke assembly, tantalum springs.

APPLICATIONS

For process water, waste treatment and water treatment in the municipal or industrial marketplace:

- Potable water disinfection, well water, surface water plants
- Slime and algae control: irrigation systems, cooling towers, rechlorination points, remote systems
- Wastewater disinfection: packaged plants, lagoons, industrial effluents
- Process water: chemical and pharmaceutical manufacture; food (washdown, canning, bleaching, taste and odor control)
- Cyanide, chromium removal: metal finishing wastes
- Recreation water: swimming pools, fountains, spray ponds

TECHNICAL DATA

Quality Standard: ISO 9001

Capacities: Standard dual-rate indicating flowmeters are available with the following capacities: 4, 10, 25, 50, 100 PPD (75, 200 g/h, 0.5, 1, 2 kg/h) of chlorine gas.

Flowmeter: The minimum feed capacity for every gas flowmeter is 1/20th of the maximum capacity. Accuracy is within ±4% of maximum flowmeter capacity.

OPERATION

Vacuum System

Water flowing through the ejector venturi, creates a vacuum which opens the check valve in the ejector. The vacuum is carried through the vacuum line to the vacuum regulator where the pressure differential created causes the inlet valve at the vacuum regulator to open, initiating gas flow. A spring opposed diaphragm in the vacuum regulator, regulates the vacuum. The gas passes under vacuum through the flowmeter, the rate control valve, the vacuum line and to the ejector. Here the gas is thoroughly mixed with water and applied as a solution (Figure 1).

The system is completely under vacuum from each ejector to the vacuum regulator inlet safety valve. If the water supply to any ejector stops or vacuum is lost for any other reason, the spring loaded inlet valve immediately closes and isolates the gas supply. If the gas source is depleted, the unit seals to prevent moisture from being drawn back into the gas source. When more than one feed point is desired multiple flowmeters and ejectors can be supplied.

Model 4 8 1 C

Maximum Capacity
1 - 100 PPD/2 kg/h

Gas Handled
C - Chlorine

Vacuum Regulator Mounting
1 - Cylinder or manifold mounted with rate valve
3 - Cylinder or manifold mounted with remote meter(s) and rate valve

AUTOMATIC SWITCHOVER

For uninterrupted gas feeding on a round-the-clock basis, an automatic switchover system is required. Each system consists of two vacuum regulators, one vacuum type automatic switchover module, one ejector and one remote meter panel. An automatic switchover module allows gas to flow under vacuum from the regulator in service through the switchover module to the remote meter panel and the ejector, until that source is depleted. The vacuum sealing valve on the regulator then closes and the vacuum level in the system increases, initiating the spring-loaded toggle assembly in the switchover module. (Figure 2) The open valve on the depleted source closes while the valve on the standby source opens to permit gas flow. When a fresh gas supply replaces the depleted source it will automatically be placed in standby. The fresh supply will not be accessed until the supply in service is exhausted.

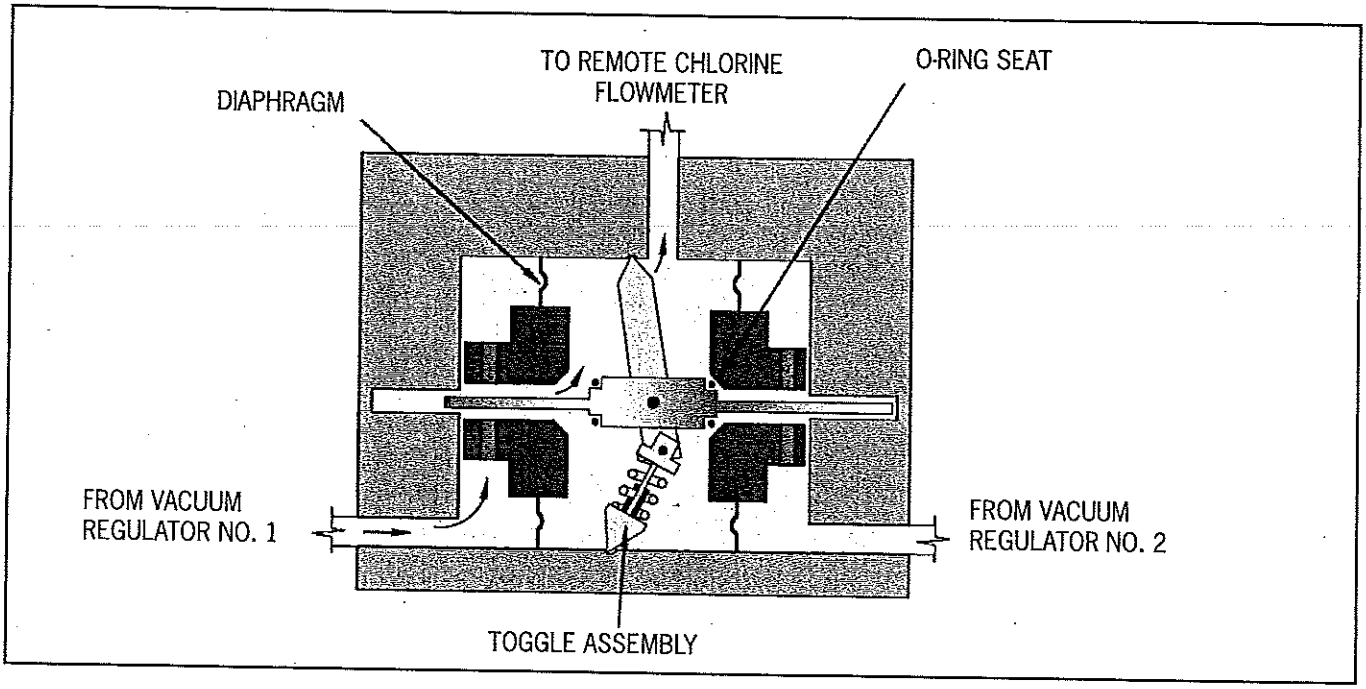


Figure 2 - Automatic Switchover Flow Diagram

Warranty and Capability

Severn Trent Services offers a limited three (3) year warranty on the Model 480 chlorinator and a limited lifetime warranty on the springs and Halar diaphragm.

Severn Trent Services is ISO 9001 certified to provide quality and precision materials. Disinfection technologies, water quality monitors and instrumentation for water and wastewater are areas of specialization. Over 35 years of industrial and municipal application experience in the water and wastewater industries is incorporated into the equipment design to provide high quality comprehensive solutions for the global market.

Brief Specification

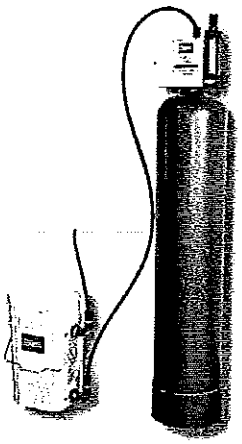
The chlorinator design shall be of the vacuum operated, solution feed type. The chlorinator shall be constructed of materials suitable for wet or dry gas service. All springs used in the vacuum regulator shall be of tantalum alloy. The rate valve and seat shall be solid silver. A double-thickness diaphragm shall be provided for vacuum regulation. The rate of gas feed shall be set manually and shall remain constant until manually changed. The gas shall flow at sonic velocity and a differential pressure regulator shall not be required.

The vacuum regulator shall mount directly on the container valve by means of a corrosion resistant yoke assembly. A spring-opposed inlet valve shall close tight upon loss of vacuum. Each vacuum regulator shall be equipped with a loss-of-gas indicator, and a gas flowmeter. A spring-loaded diaphragm actuated pressure relief valve integral to the vacuum regulator shall be provided to relieve gas pressure. The inlet capsule shall be a complete module, installed without the use of any tools.

The vacuum producing device shall be an ejector with a spring-loaded check valve to prevent flooding of the vacuum regulator or a CHLOR-A-VAC® chemical induction unit, Series 1420.

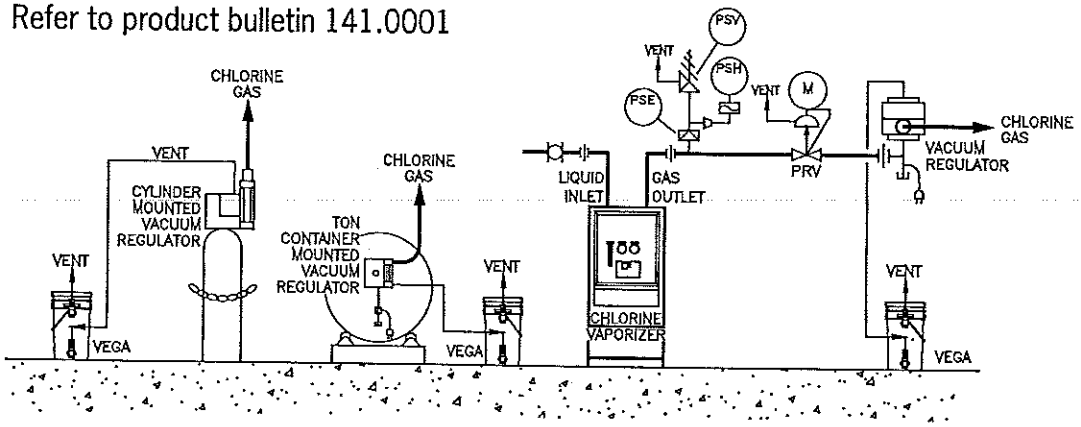
Automatic switchover shall be provided with automatic reset and integrally mounted vacuum regulator flow indicator.

The chlorinator shall be Severn Trent Services ADVANCE™ Model 481C.



Option: VEGA - Vent Exhaust Gas Arrestor

Refer to product bulletin 141.0001



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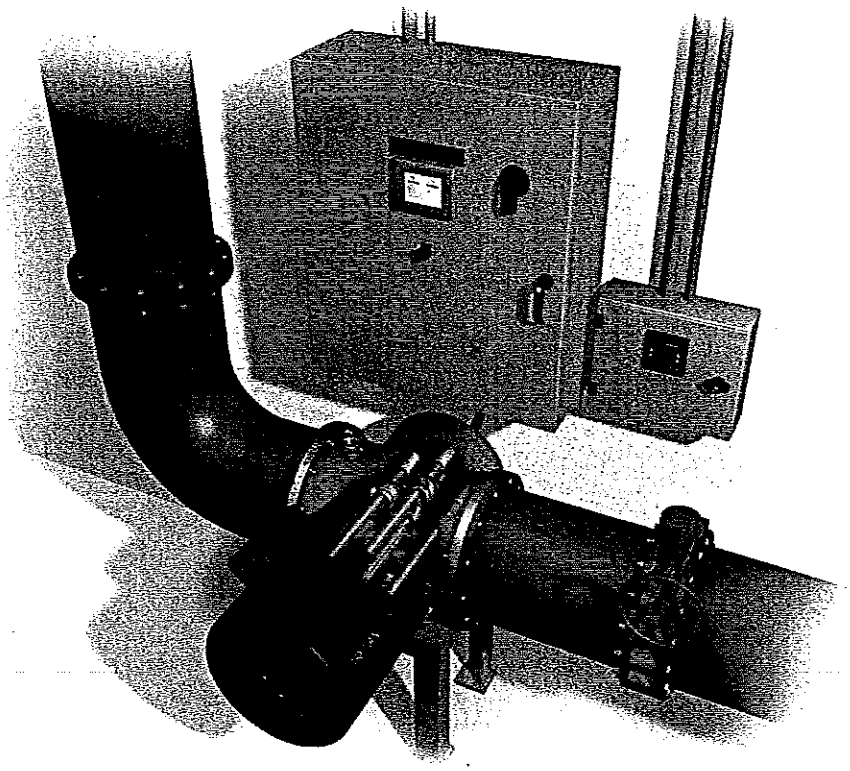
100.0001.13 JUN/10

APPENDIX E

UV PRODUCT INFORMATION

TROJANUVSWIFT™

PROPOSAL FOR THE CITY OF AMHERST, MA (CENTENNIAL WTP), MA
QUOTE: 113632
Sep 20 2010



The TrojanUVSwift™ is currently being used to treat **over 2 billion** gallons a day in municipal drinking water plants around the world. With **over 500** installed reactors, the TrojanUVSwift™ has demonstrated its proven, validated solutions for disinfection and taste & odor treatment.

September 20, 2010

TROJANUVSWIFT™

In response to your request, we are pleased to provide the following TrojanUVSwift™ proposal for the **Amherst, MA (Centennial WTP)** project.

The TrojanUVSwift™ is well suited to meet current and upcoming regulations to protect the public from various pathogens including the chlorine-resistant *Cryptosporidium* and *Giardia*. The system uses high-intensity, medium-pressure lamps to minimize footprint and headloss. The ActiClean™ cleaning system meets NSF 60/61 compliance and eliminates routine quartz cleaning. All Trojan installations are supported by a global network of certified Service Representatives, providing local service and support.

Please do not hesitate to call us if you have any questions regarding this proposal. Thank you for the opportunity to quote the TrojanUVSwift™ and we look forward to working with you on this project.

With best regards,

Stephen Payler
3020 Gore Road
London, Ontario N5V 4T7
Canada
(519) 457-3400 ext. 2577
spayler@trojanuv.com

Local Representative:
Rep Name
Rep Company
Rep Address
Rep City, Rep State
Rep Postal Code
Rep Country

DESIGN CRITERIA

Amherst, MA (Centennial WTP)

Design Flow:	**1.5 MGD(US)**
UV Transmittance:	**80%** (minimum)
Disinfection Requirement:	**1 log Giardia Removal**
Validation:	Full Compliance with USEPA UV Guidance Manual System Materials – NSF 61 ActiClean™ Gel – NSF 60

TROJANUVSWIFT™

DESIGN SUMMARY

QUOTE: 113632

Based on the design criteria, the TrojanUVSwift™ proposed consists of:

REACTOR	
Total Number of SS316L Reactors:	**2**(including 1 redundant reactor)
Model Number:	**2L12**
Number of Lamps per Reactor:	**2**
Number of Intensity Sensors:	**1 per lamp**
Total Number of Lamps:	**4** (including redundant reactor)
Maximum Flow per Reactor:	**1.5 MGD(US)**
Total Headloss at Peak Design Flow:	**1.4 in-H2O**
Automatic Chemical / Mechanical Cleaning:	**Trojan ActiClean™ Included**
Standard Spare Parts / Safety Equipment:	**2 lamps/sleeves, operators kit**
UV PANELS	
Control Power Panels (CPP) Quantity:	**2(1 per reactor)**
Controller:	**Allen Bradley Compact Logix L35**
Operator Interface:	**Allen Bradley Panelview+ 700**
OptiView™ Transmission Monitor:	**Included**
EQUIPMENT LAYOUT & DIMENSIONS	
Reactor Flange Size:	**12" ANSI 150 lb**
Reactor Length (Flange to Flange):	**20¾" (527mm)**
Control Power Panel Dimensions (WxHxD):	**36" x 48"x 18" (Wall-Mounted)**
Distance from CPP to Reactor:	**40'**
ELECTRICAL REQUIREMENTS	
1. Each Control Power Panel (one per reactor) requires an electrical service of one (1) 240V, 60Hz, 1-phase, 3-wire + ground **2.** The OptiView™ Panel (optional) requires an electrical service of one (1) 120V, single phase, 2 wire + ground, 250VA. **3.** Electrical disconnects required per local code are not included in this proposal.	

COMMERCIAL INFORMATION

Total Capital Cost: $137,846.00 (USD)

This price excludes any taxes that may be applicable and is valid for 90 days from the date of this letter.

OPERATING COST ESTIMATE

Operating Conditions

Average Flow: **0.9 MGD(US)**
UV Transmittance: **80%**
Yearly Operating Hours: **8760 hours**
Number of Reactors Operating at Average Flow: **1**

Power Requirements		Lamp Replacement	
Average Power Draw:	**1.8 kW**	Number lamps per year:	**4**
Cost per kW hour:	**$0.05**	Price per lamp:	**$366**
Annual Power Cost:	**$791**	**Annual Lamp Replacement Cost:**	**$1464**
Total Annual O&M Cost: $2255			

This cost estimate is based on the average flow and UV transmittance listed above. Actual operating costs may be lower due to the TrojanUVSwift™ automatic dose pacing control system. As UV demand decreases, due to a change in operating conditions, the power level of the lamps decreases accordingly. The dose pacing system minimizes equipment power levels while the target UV dose is maintained to ensure disinfection at all times.

EQUIPMENT WARRANTEES

1. Trojan Technologies warrants all components of the system (excluding UV lamps) against faulty workmanship and materials for a period of 12 months from date of start-up or 18 months after shipment, which ever comes first.

2. UV lamps purchased are warranted for 5,000 hours of operation or 3 years from shipment, whichever comes first. The warranty is pro-rated after 3,000 hours of operation. This means that if a lamp fails prior to 3,000 hours of use, a new lamp is provided at no charge.

3. Electronic ballasts are warranted for 5 years, pro-rated after 1 year.

From: Christina L. Stauber [mailto:CLStauber@tigheBond.com]
Sent: Tuesday, September 21, 2010 10:57 AM
To: 'Mike Smith'
Subject: RE: UV system for Centennial WTP

Thank you Mike! Can you also provide a quote with NO redundant reactor?
Just one reactor and one control panel, etc? I think Steve missed that request.

Thanks,

-Christina

-----Original Message-----
From: Mike Smith [mailto:msmith@themahercorp.com]
Sent: Monday, September 20, 2010 11:23 AM
To: Christina L. Stauber
Subject: FW: UV system for Centennial WTP

Christina:

See updated proposal.

Mike

-----Original Message-----
From: Payler, Stephen [mailto:spayler@trojanuv.com]
Sent: Monday, September 20, 2010 10:58 AM
To: Mike Smith
Cc: Duncan, Una
Subject: RE: UV system for Centennial WTP

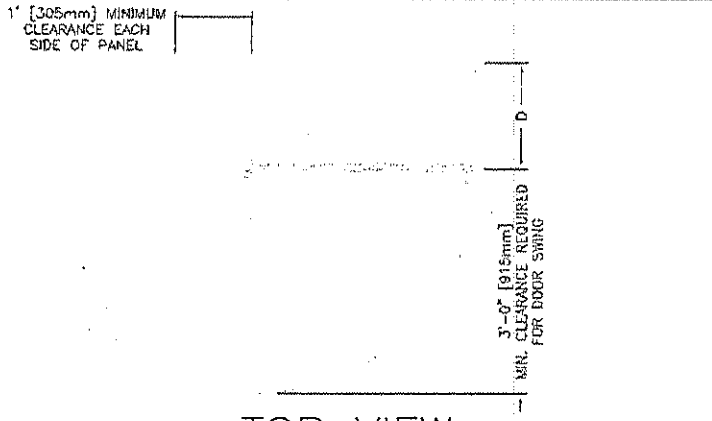
Mike,
Updated quote as requested, also to remove the redundant reactor there would be a cost savings of $60,000 dropping the total cost to $77,846

regards,
Stephen Payler
TROJANUV

3020 Gore Road
London, Ontario N5V 4T7
T 519.457.3400 F 519.457.3030
www.trojanuv.com

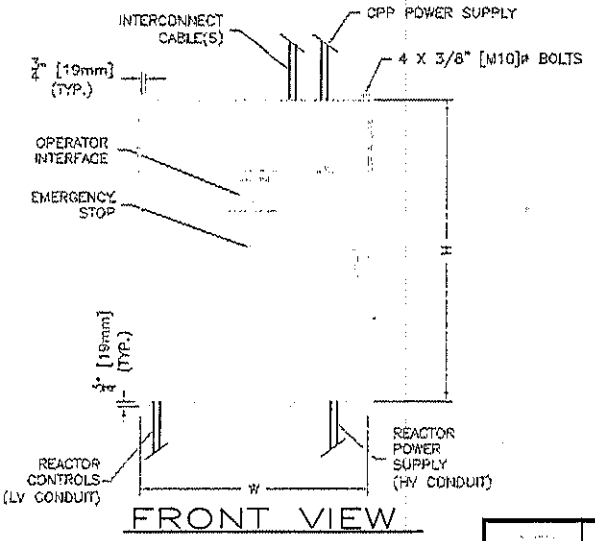
Water Confidence

-----Original Message-----
From: Mike Smith [mailto:msmith@themahercorp.com]
Sent: September 20, 2010 9:18 AM
To: Payler, Stephen
Cc: Duncan, Una
Subject: FW: UV system for Centennial WTP



TOP VIEW

SCALE:AS SHOWN



FRONT VIEW

SCALE:AS SHOWN

NOTE:

1. CONTROL POWER PANEL COLOR TO BE ASA 61 GRAY EPOXY, MATERIAL TO BE MILD STEEL AND PANEL TO BE WALL MOUNTED.
2. INTERCONNECT CABLE TO BE [illegible] OR [illegible] LONG.
3. CONDUIT SUPPLIED BETWEEN CPP AND REACTOR.
4. PANEL WEIGHT L12 = [illegible]
5. METRIC DIMENSIONS SHOWN ARE STRAIGHT CONVERSIONS FROM IMPERIAL.
6. FOR CORRESPONDING REACTOR DRAWING, SEE DRAWING SW0003D01 FOR A REACTOR IN A HORIZONTAL ORIENTATION OR SW0013D01 FOR A REACTOR IN A VERTICAL ORIENTATION.

No.	DESCRIPTION	FROM	TO
1	CONTROL POWER PANEL (CPP) POWER SUPPLY 480V, 3 PHASE 4 WIRE + GROUND OR, 415V, 3 PHASE 3 WIRE + GROUND OR, 240V, 3 PHASE 3 WIRE + GROUND OR, 240V, 1 PHASE 3 WIRE + GROUND 2L12 = 7 KVA UNBALANCED LOAD 4L12 = 13 KVA UNBALANCED LOAD	DISTRIBUTION PANEL (DP) (BY OTHERS) (NOT SHOWN)	CPP (TOP OF PANEL)
2	REACTOR POWER SUPPLY (HV CONDUIT) (CONDUIT AND CABLING PROVIDED BY TROJAN)	CPP (UNDER SIDE OF PANEL)	REACTOR
3	REACTOR CONTROLS (LV CONDUIT) (CONDUIT AND CABLING PROVIDED BY TROJAN)	CPP (UNDER SIDE OF PANEL)	REACTOR
4	DISCRETE UV SYSTEM STATUS INFORMATION SYSTEM ON/OFF STATUS – 2 CONDUCTORS COMMON CRITICAL ALARM – 2 CONDUCTORS COMMON MAJOR ALARM – 2 CONDUCTORS COMMON MINOR ALARM – 2 CONDUCTORS SYSTEM READY STATUS – 2 CONDUCTORS DISCRETE REMOTE ON/OFF CONTROL – 2 CONDUCTORS DOSE DELIVERED – 4–20mA ANALOG OUTPUT (ISOLATED) (OPTIONAL)	CPP (TOP OF PANEL)	PLANT PLC (BY OTHERS) (NOT SHOWN)
6	DISCRETE COOLING WATER VALVE OPEN/CLOSE CONTROL – 10 CONDUCTORS (OPTIONAL)	CPP (TOP OF PANEL)	VALVE (BY OTHERS)
7	FLOW METER (OPTIONAL) 4–20mA, ANALOG INPUT (ISOLATED) (BY OTHERS)	FLOW METER (BY OTHERS) (NOT SHOWN)	CPP (TOP OF PANEL)

DIMENSION		
W	H	D
36" 914mm	48" 1219mm	18" 406mm

Trojan Technologies Inc.

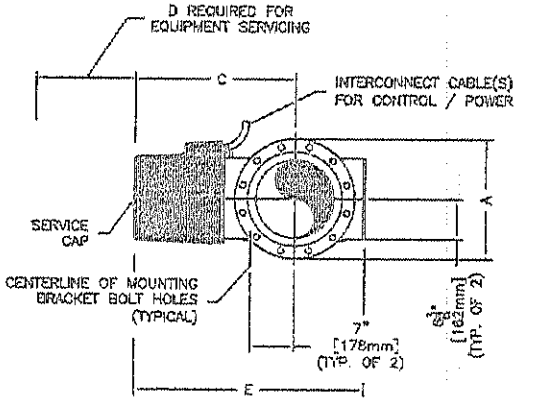
DESCRIPTION: UVSWIFT, 12 CONTROL POWER PANEL

STANDARD DRAWING NO.: SW0002

DRAWN BY :	DATE :
CHECKED BY :	DATE :
APPROVED BY :	DATE :
SCALE (11x17) :	LOG NUMBER :

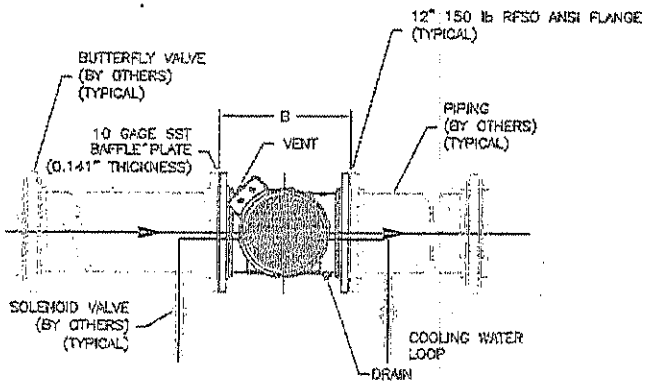
PROJECT NO.: N/A

DWG NO: D01 REV: D



SIDE VIEW

SCALE:AS SHOWN



FRONT VIEW

SCALE:AS SHOWN

NOTES:

1. CHAMBER MATERIAL TO BE TYPE 316L STAINLESS STEEL.
2. MAXIMUM OPERATING PRESSURE TO BE 150 PSI.
3. TROJAN RECOMMENDS THAT VALVES ARE USED TO ISOLATE THE REACTOR FROM PLANT FLOW FOR SERVICING. (NOTE: LAMP CHANGE OUT CAN BE DONE ON-LINE) ALL VALVES ARE TO BE SUPPLIED BY OTHERS.
4. 4L12 REACTOR WEIGHT: DRY [illegible] / WET [illegible]
5. METRIC DIMENSIONS ARE STRAIGHT CONVERSIONS FROM IMPERIAL.
6. REFER TO DRAWING SW0002D01 FOR CORRESPONDING CPP DRAWING.

No.	DESCRIPTION	FROM	TO
1	CONTROL POWER PANEL (CPP) POWER SUPPLY 480V, 3 PHASE 4 WIRE + GROUND OR, 415V, 3 PHASE 3 WIRE + GROUND OR, 240V, 3 PHASE 3 WIRE + GROUND OR, 240V, 1 PHASE 3 WIRE + GROUND 2L12 = 7 KVA UNBALANCED LOAD 4L12 = 13 KVA UNBALANCED LOAD	DISTRIBUTION PANEL (DP) (BY OTHERS) (NOT SHOWN)	CPP (TOP OF PANEL)
2	REACTOR POWER SUPPLY (HV CONDUIT) (CONDUIT AND CABLING PROVIDED BY TROJAN)	CPP (UNDER SIDE OF PANEL)	REACTOR
3	REACTOR CONTROLS (LV CONDUIT) (CONDUIT AND CABLING PROVIDED BY TROJAN)	CPP (UNDER SIDE OF PANEL)	REACTOR
4	DISCRETE UV SYSTEM STATUS INFORMATION SYSTEM ON/OFF STATUS – 2 CONDUCTORS COMMON CRITICAL ALARM – 2 CONDUCTORS COMMON MAJOR ALARM – 2 CONDUCTORS COMMON MINOR ALARM – 2 CONDUCTORS SYSTEM READY STATUS – 2 CONDUCTORS DISCRETE REMOTE ON/OFF CONTROL – 2 CONDUCTORS DOSE DELIVERED – 4–20mA ANALOG OUTPUT (ISOLATED) (OPTIONAL)	CPP (TOP OF PANEL)	PLANT PLC (BY OTHERS) (NOT SHOWN)
6	DISCRETE COOLING WATER VALVE OPEN/CLOSE CONTROL – 10 CONDUCTORS (OPTIONAL)	CPP (TOP OF PANEL)	VALVE (BY OTHERS)
7	FLOW METER (OPTIONAL) 4–20mA ANALOG INPUT (ISOLATED) (BY OTHERS)	FLOW METER (BY OTHERS) (NOT SHOWN)	CPP (TOP OF PANEL)

DIMENSION				
A	B	C	D	E
19" 483mm	20 3/4" 527mm	25-1/4" 642mm	15" 381mm	38-3/8" 824mm

Trojan Technologies Inc.

DESCRIPTION: UVSWIFT, 12 REACTOR (HORIZONTAL)

DRAWN BY : [illegible] DATE : [illegible]

CHECKED BY : [illegible] DATE : [illegible]

APPROVED BY : [illegible] DATE : [illegible]

SCALE (11x17) : [illegible] LOG NUMBER :

STANDARD DRAWING No. SW0003

PROJECT NO. N/A

ISSUE NO. D01 REV. D